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THE GEOGRAPHICAL JOURNAL

Vol LXXVI No 4 October 1930

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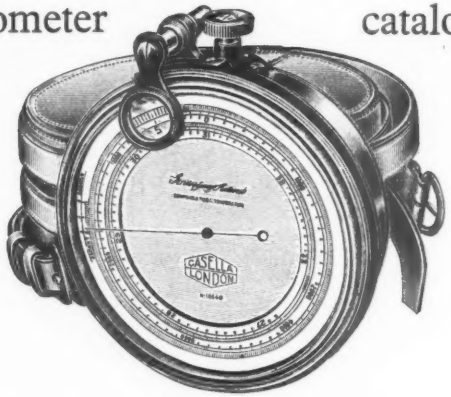

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The
GEOGRAPHICAL JOURNAL

Vol LXXVI No 4 R.G.S. October 1930

ISLAND-REEFS OF THE QUEENSLAND COAST: *The third part, continued from page 214, of the paper read at the Evening Meeting of the Society on 16 December 1929, by*

MICHAEL SPENDER

PART III. THE LABYRINTH

"We could have wished . . . he could have employed them in examining what has never yet been done, the structure at different depths of those wall-sided fabrics, whose perpendicular columns descend to the very bed of the ocean, and in endeavouring to trace the history of those insignificant beings, whose means appear to us so inadequate to the end, and whose stupendous productions extend for thousands of miles."—From a review of D'Entrecasteaux, "Voyage au Recherche de La Pérouse," *Quarterly Review*, February 1810.

I HAVE described in the first and second parts of this paper a peculiar type of island-reef, of which Low Isles and Three Isles were presented as examples. The authority to consider them members of a class had been Mr. Steers,* and as yet we have only considered our particular examples isolated from their fellows. There are along this coast a great many of these islands, a number of which Mr. Steers and I were able to visit while we were cruising in the launch *Tivoli*. In assuming a familiarity with the island-reef forms of Parts I and II and proceeding to consider the distribution and nature of all the reefs in the neighbourhood, we break ground with a whole set of new ideas.

The material for what follows is not all of my own observation: in particular, the existing Admiralty surveys of the Queensland coast provide material which has as yet by no means been exhausted. First-hand observations were obtained while we were on the *Tivoli*, during which cruise Mr. Steers and I visited nearly all the islands described on the charts as low and wooded, from Townsville as far north as the Flinders group of islands in Princess Charlotte Bay. We also examined somewhat cursorily Arlington Reef, Michaelmas Reef, and "Ef" Reef. In June 1929 a deliberate programme was carried out on Yonge Reef by much the same party as visited Three Isles in May. In this subsidiary excursion we took advantage of Lizard Island, a granite mountain some 1000 feet high happily placed in the sea 10 miles landward of the outer barrier reefs in

*"The Queensland Coast and the Great Barrier Reefs," *G.J.*, 74, 1929, pp. 232–257 and 341–370.

lat. 14° 40′ S. It provided an exceedingly good base for what might have been some exceptionally interesting comparisons between reefs of different kinds found in a comparatively small area. Unfortunately an unexpectedly violent winter gale obliterated half this scheme by detaining us helplessly weather-bound on the mountain, where we were only able to work on the small associated reefs. Yet at the time we were grateful enough to have been able on four con-

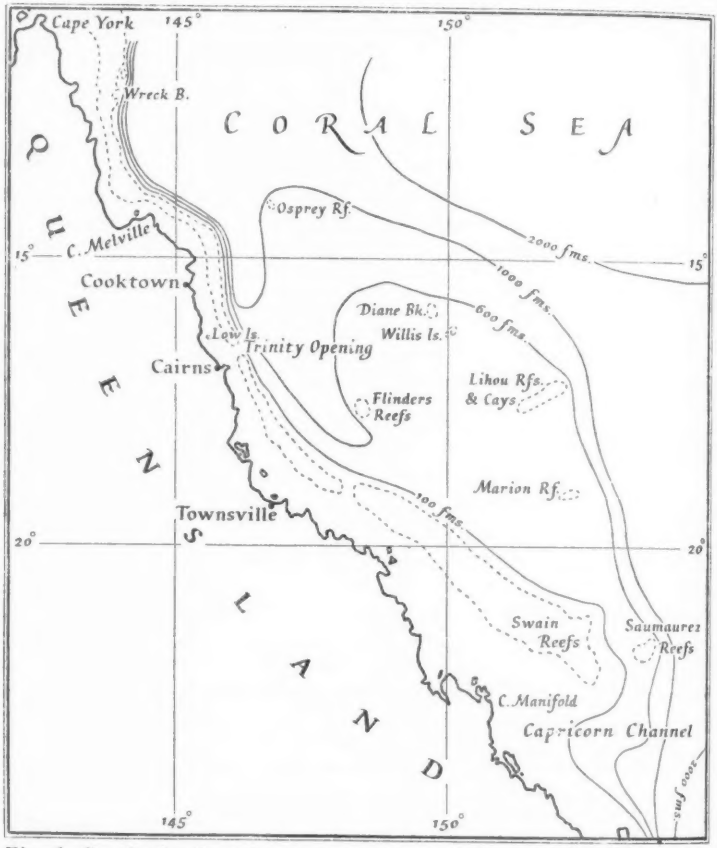


Fig. 6. Sea depths about the Great Barrier Reef: from Admiralty chart data

secutive days to steam to one of the outer barrier reefs and do our work in fine weather. At the new-moon tides of July 1929 Ruby Reef and Escape Reef, also of the outer barrier series but south of Yonge Reef, were visited by most of the expedition. Pixie Reef and Batt Reef I was not able to see, but other members have freely given me photographs and descriptions.

In effect, the above list signifies that we had the opportunity to form a reasonably good idea of the reef system between the parallels 16° 30′ S. and

14° 30′ S. This was qualified with enough acquaintance with the mainland abreast of Low Isles to know its character, and to be able to understand, after some visits to Cooktown and the mainland about Cape Bedford, how completely the coast alters in the neighbourhood of the Endeavour Estuary when the geology changes from a mainly granite formation to sandstone. This in its turn affects the conditions at sea, and therefore for the growing coral.

The first important thing to be established is that no one description is adequate for the whole of the Great Barrier Reef, and that one of the abrupt points of change is off Cairns, at Trinity Opening. This opening is in 16° 30′ S. and is the southern limit of the section of the reef that will be our special consideration. Fig. 1 (Part I) from the Admiralty Chart 2924 shows but a few miles of the barrier reefs south of the opening; nevertheless this short stretch is already characteristic of the reef system for a long way towards the south. These characteristics may be summarized thus: The 100-fathom line is some miles to seaward of the outermost reefs and is marked by no chain of linear reefs; the reefs between this line and the mainland coast seem to be distributed at random. The slope outside the platform of shoal water from which the reefs rise, which in the north is bounded by the 100-fathom line, is, for a reef profile, gradual*; it becomes less steep, and less definite, progressively as far south as Swain Reefs in lat. 21° S.†; as it approaches this latitude from the north, the whole reef system broadens and increases its distance from the coast. Taken as a whole, the appearance is of a gradual transition from a coral slope in the north, where the reefs are "steep-to," their seaward edges within a few cables of 100-fathom soundings, to a continental profile in the south.

Outside Swain Reefs the platform is very ill-defined: there is a gradient of 1 in 30 (less than 2°) outside these so-called barrier reefs. This gentle slope, which a motor car would not notice, leads down to a 200-fathom platform, a little way beyond which the bottom drops fairly steeply to 1000 fathoms.

Not far north of Trinity Opening the reefs assume an arrangement unlike anything to the south: a system of linear reefs, separated by narrow openings, forms a barrier at the edge of the general platform. The 100-fathom line is so close without this chain of reefs that it is not charted for the most part. For 300 miles a series of ribbon-like arcs of reef, about half a mile wide, separate the ocean from the protected sea: the seaward slope outside them is abrupt, reaching 1000 fathoms in 4 miles. The term "Barrier Reef" can be used here if ever it can properly be used on the Queensland coast. As far north as the 12th parallel this barrier follows the trend of the coast at a distance of about 30 miles. In this section the other reefs of the protected sea, between coast and barrier, are not scattered casually but seem to be distributed in a regular and systematic way possibly without parallel in any other reef system.

In order to call attention to a point of this sort, there is a danger of overstressing it; but the definite indication that the reefs inside the barrier form a series about halfway between the mainland coast and the barrier cannot be passed over. Jukes stated the matter firmly‡: "From the examination of our charts it

*Professor J. Stanley Gardiner, "Submarine Slopes," *G.J.*, 45, 1915, pp. 202–219.

†See Fig. 6 and section, Fig. 8.

‡Jukes, J. Beete, 'Narrative of the Surveying Voyage of H.M.S. *Fly*.' 2 vols. London, 1847. Vol. i, p. 317. See the whole of Chapter XIII for a most able geographical account.

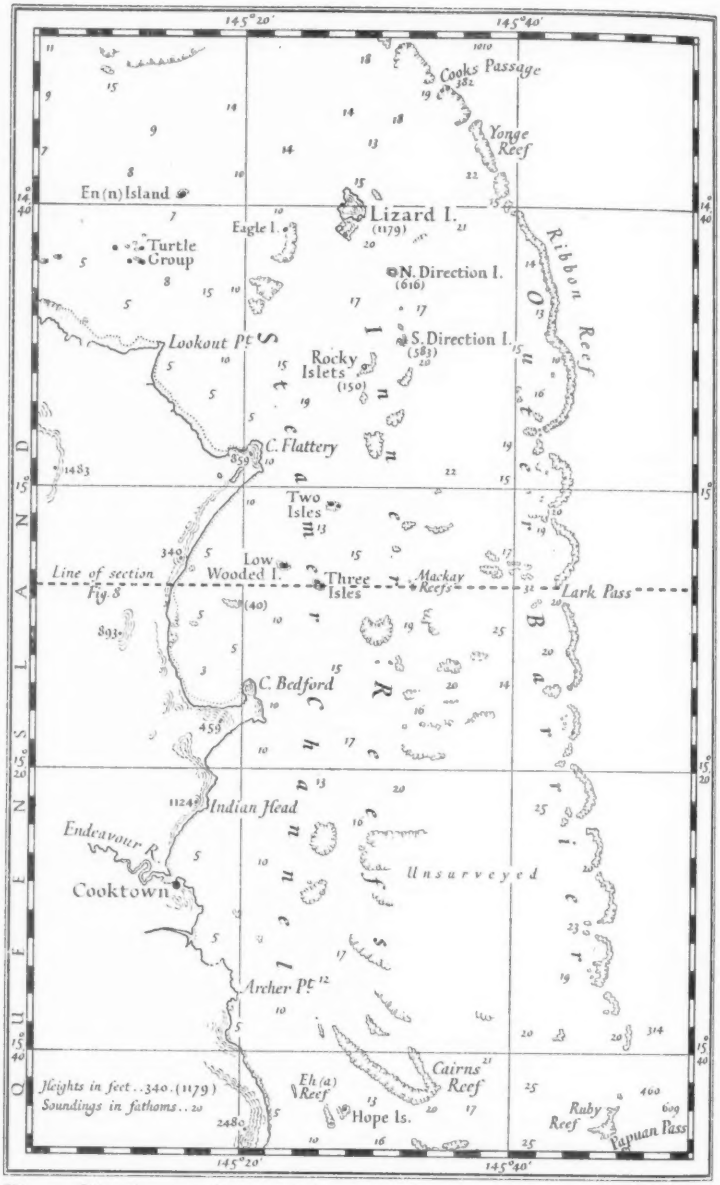


Fig. 7. Sketch-map of part of the Queensland coast and adjacent Barrier Reefs, showing the position of the island-reefs with respect to the other reef systems: from Admiralty Chart 2923

would appear that the normal condition of the long mass of reefs is, that the outer barrier should be narrow, rising precipitously from a great depth, and running more or less nearly in a straight line, and inside this outer barrier there should be a clear space about 20 fathoms deep and several miles wide, between which space and the land should be another body of reefs."

Jukes distinguished reefs of two kinds: those of the outer barrier which he called linear reefs, and those of the protected sea which he called inner reefs. The inner reefs, I suggest, normally form a series north of Trinity Opening. The channel between this series and the outer barrier, which Jukes recognized, goes unnamed. That between this inner series and the mainland I call the steamer channel, for it is now the regular track of shipping proceeding between Torres Straits and the ports of the eastern seaboard of Australia. It was the business of H.M. Survey Ship *Fly*, where Jukes, as naturalist and collector, was receiving hospitality, to make this track navigable for seamen.

To Jukes' two kinds of reef I wish to add a third, the island-reefs of Parts I and II. The fact that they are reefs is more essential than the bare achievement of fulfilling the definition, "land surrounded by water." A concluding distinction between the Great Barrier system as it is south of Cairns compared to north of it is in the distribution of these island-reefs. All occur north of Trinity Opening and most between the Opening and Wreck Bay. A particularly essential feature of their distribution is that all of them are in the steamer channel.

This term, island-reefs, which has to be qualified by "of Parts I and II," is troublesome, since it might appear to include reefs bearing islands low and wooded such as the Capricorns. Provisionally the term must be used and understood in what follows to signify the specialized type having a vegetated sand-cay, ramparts, and a mangrove swamp. The difficulty of selecting satisfactory nomenclature will be understood when it is realized that there are intermediate reef forms between this island type and those reefs from which debris is altogether absent.

Flinders in 1802 cruised up the protected sea as far as lat. 19° S., where he discovered a passage by which he could pass through the reefs to the deep sea beyond the barrier. In his general account of the region, he writes, describing the sea between the mainland and the barrier, "Numerous islands lie scattered in the enclosed space, but so far as we are acquainted there are no other coral banks in it than those by which some of the islands are surrounded."* He was familiar only with the southern part of the Barrier: in the sentence quoted he has picked out precisely a characteristic which is a distinction between the reef system north and south of Cairns. There are numerous "high" islands† and rocks of continental origin in the southern part, but no coral reefs as usually understood are situated in the steamer track, whereas to the north high islands are sparsely distributed, but reef obstructions are frequent. It is most remarkable that all but a very few of these reefs are island reefs, and that the island reefs are restricted to this inner channel; it is in almost every case simple to decide whether a reef belongs to the inner series which bounds the steamer channel or to the island series which obstructs it, and in only one case is a

*Flinders, M., 'A Voyage to Terra Australis.' 2 vols. London, 1814. Vol. ii, p. 102.
†Cf. Steers, *loc. cit.*

reef which might be described as a member of the inner series capped by an island.

The part of the Great Barrier then, between 12° 30′ S. and 16° 30′ S.—that is between Trinity Opening and Wreck Bay—is notable in that it demonstrates a reef system different from the other parts of the Barrier and which from end to end is more consistent and regular than any other comparable reef system of which I know an account.

The Great Barrier varies much in form at different places in its 1200-miles'

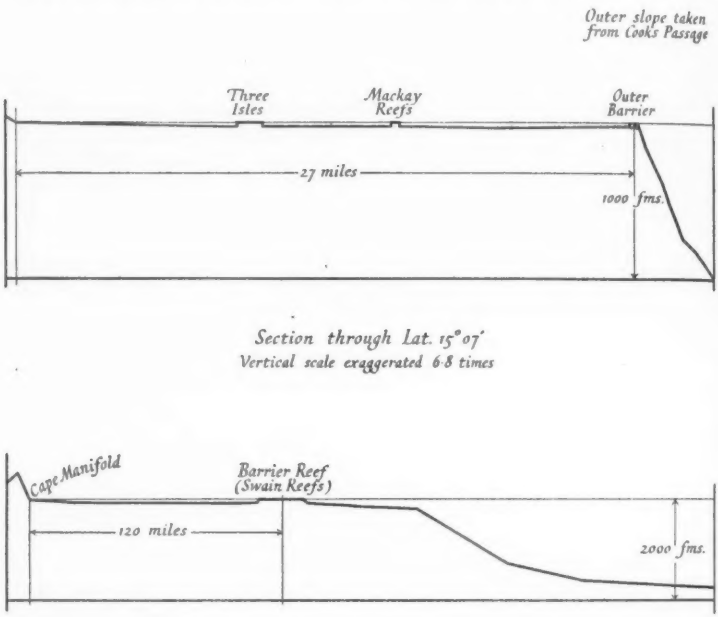


Fig. 8. Sections across the Barrier from the mainland to deep water in two different latitudes: drawn from Admiralty chart data

stretch. The first section above (Fig. 8) is taken through the reef in the latitude of Three Isles, 30 miles south of Lizard Island. It is a section across that traverse of the reef which includes the island reefs. The section shows how insignificant is the depth of the protected sea when compared with the deep ocean: in order, indeed, to show the shallow sea at all in the figure, it has been necessary to exaggerate the vertical scale nearly seven times.

This first section could fairly be described as the section of a barrier reef of the same class as the great reef about New Caledonia. Six hundred miles south the soundings are as in the second section, which shows a very different state

Phot. M. A. Spender

11. Breakers at seaward edge of Yonge Reef, June 1929

Phot. Mrs. T. A. Stephenson

12. Gap in outer edge of Yonge Reef

Phot. M. A. Spender

13. Arlington Reef, showing reef flat of an Inner Reef

14. Reef crest, Yonge Reef Phot. M. A. Spender

of affairs. The change begins a little north of Trinity Opening: the 1000-fathom contour follows the trend of the reef southward about 4 miles east of it as far as Trinity Opening, where it recurves and goes due north to Osprey Reef in the Coral Sea, 60 miles outside the barrier, and in the latitude of Cape Melville. The fortunes of this contour have been followed further, and the diagram Fig. 6 is the interesting result. The curious trough down to Trinity Opening is notable, and the trend of the contour at the southern limit of the barrier reef, where the Queensland continental shelf changes into the New South Wales shelf, is interesting enough to merit a momentary digression.

W. H. Bryan, in a paper on "The Queensland Continental Shelf,"* writes a thesis on the "basal assumption that the 100-fathom contour represents the real structural limit of the continental masses . . ." and goes on to say that "In the case of Queensland . . . it is of the utmost importance that we should realize that the 100-fathom contour represents the true edge." This is a surprising statement: the paper from which it is taken is one of a tentative nature, but it is necessary to resist such commonly employed hypotheses from becoming generally accepted truths. In some parts of the world the continental shelf is limited by the 100-fathom line; that is to say the gradient of the ocean floor at or about that depth increases to a fairly steep declivity to the ocean deeps.† But south of lat. 19° S. the 100-fathom line marks no particular incident in the form of the continent seaward of the Barrier Reef. Again Jukes says just what should be said‡: "At this point§ our examination of the southern part of the Great Barrier terminated, and so far it can hardly be said that any true barrier exists. There is merely a bank of soundings‖ running to a greater or less distance off the shore with large masses of coral reef settled upon it." Although this was written in 1847, at a much later date we have so considerable an authority as E. C. Andrews writing (he was considering Eastern Australia as a whole)¶: "Northwards again the outer edge of the shelf is represented by the Great Barrier Reef itself. . . ." His authority has been accepted for great super-structural developments of the idea that the continental shelf of New South Wales is continuous with that of Queensland *and therefore* with the Great Barrier Reef.

Figure 6 displays such adjustments as are necessary in the ideas of the relation of the barrier to the continent. From Saumaurez Reefs in lat. 22° S. in the south-east to Osprey Reef in lat. 14° S. in the north-west, there is a great bank within the 1000-fathom contour. There are indications of a trough of about 500 fathoms depth crossing it about lat. 18° S., but the greater part of this bank has less depth than 300 fathoms over it. The steepest slopes associated with it are in the neighbourhood of the 1000-fathom contour, which at the northern and southern extremities is approached by the 2000-fathom contour.

It is significant that the part of the Barrier already isolated as the northern

*Reps. Great Barrier Reef Committee, vol. ii, Brisbane, 1928, pp. 58–69.

†'Structure and Surface,' Barrington-Brown and Debenham. Arnolds, 1929.

‡*Loc. cit.*, vol. i, p. 321.

§Lat. 21° S.

‖"Soundings." O.E.D. quotes 'Smith's Sailors' Word Book' (1867). "To be in soundings is limited in common parlance to parts not far from the shore, and where the depth is about 80 to 100 fathoms."

¶*Proc. Linn. Soc. N.S.W.* Vol. 27, 1902.

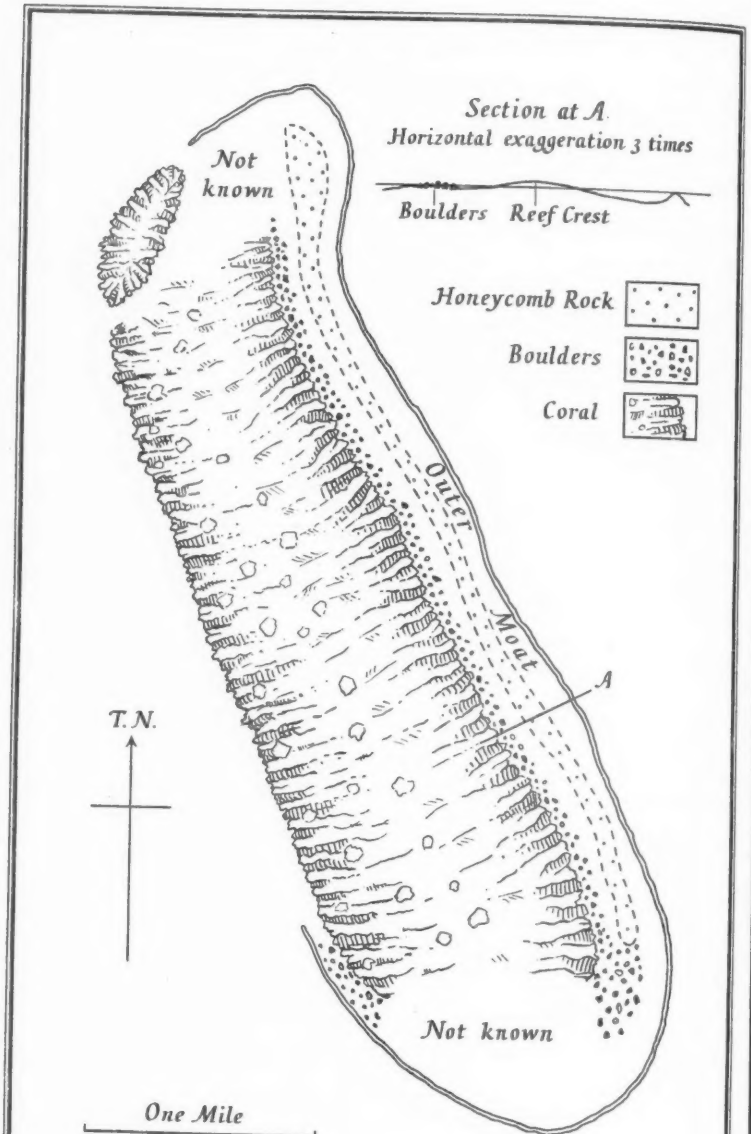


Fig. 9. Sketch of an outer barrier-reef: general form from Captain Blackwood's survey; width of zones paced

section should be where the reefs are closely approached by the 1000-fathom contour. At Trinity Opening this parts company with the Barrier, and here the form of the reefs changes. In the case of the stretch of Reef for 300 miles north of Trinity Opening, the part that is our special consideration, we have a barrier reef at the edge of a platform-like shelf, which, with its steep gradient down to the ocean deeps, resembles the barrier reefs of the islands of the Pacific.

It seemed to us that as much knowledge as possible of the structure of the individual reef types was a necessary prelude to a discussion of any aspect of any part of the reef. In those places where we were able to examine the outer reefs they differed much from the inner reefs of the protected sea, which in their turn are different from the island reefs of Parts I and II. A chance remark of Flinders*: "In Swain's reefs the individual reefs on the outer edge of the group are scarcely to be distinguished in form from those inside them" is particularly relevant in this connection. It is possible that the outer chain of the northern part of the Barrier is formed of reefs categorically different from any of those casually distributed on the bank of soundings to the southward.

Ribbon Reef† was the first outer reef that we visited. This is of the linear barrier series, running south from lat. 14° 40½′ S. for 16 miles, narrow throughout its length. I was extremely curious to see this structure, being sceptical of the accuracy of its charted form. When we came to it we found that Captain Blackwood of H.M.S. *Fly* had ordered, as usual, a most precise representation of the reef, although the work was done in 1843 with the unhandy craft of those times. From our launch's mast-head the narrow ribbon of dry reef could be seen to the extreme distance of visibility in either direction, separating the ocean from the protected sea. Since the reef runs north-north-west and south-south-east in parts, the inner edge is incompletely sheltered from the short seas raised by the Trade. The drying reef is about ½ mile wide, but the submerged parts and the zone of coral heads and patches which in many reefs are more extensive than the part that dries, are here very narrow: soundings of 15–19 fathoms can be obtained very close to the western or inshore edge of the reef.

The reef was not chosen for the detailed work of the whole party largely on account of the poor shelter and anchorage provided, especially as Yonge Reef,‡ lat. 14° 35′ S. and 5 miles north of Ribbon Reef, is so conveniently worked from Lizard Island. At the south-eastern extremity of Yonge reef there is a horn-shaped ridge of reef enclosing within its re-curve sheltered water with soundings of 8–10 fathoms between the coral-heads, shoaling as the main reef is approached. This is an excellent anchorage for small craft. A further convenience is that the course from Lizard Island is such that in normal Trade weather the vessel can just make it close-hauled. If the return course to the northern cape of Lizard Island has to be made during or after sunset, it is clear of all dangers and can be sailed with a free sheet.

At Yonge Reef we found the same features as on Ribbon Reef. When later we visited Ruby Reef (lat. 15° 45′ S.) and Escape Reef (lat. 14° 15′ S.) we found it easy to describe them in the terms of Yonge Reef, which we have come to

Loc. cit., vol. ii, p. 101.

†Admiralty Correspondence docket H 5103/29.

‡*Ibid.* Named after the leader of the 1928 Expedition.

think of as the archetype of outer reefs: certainly there was a fascinating completeness in the development of its surface features that made one think of the other reefs visited as less perfect forms.

There was no opportunity to make a survey or carry out any levelling. But the background that we all had of six months' intensive work on the reefs of Low Isles and elsewhere had trained us to recognize, and all but map and level by eye alone, features not at all obvious to those unaccustomed to the work. A sketch of Yonge Reef is shown in Fig. 9.

Plate 11 shows the ocean swell breaking on the outer edge of Yonge Reef during the fine weather of our visit. Cook, speaking of the more usual condition, says: "The Large Waves of the Vast Ocean meeting with so sudden a resistance makes a most Terrible Surf, breaking mountains high, especially as in our case, when the General Trade Wind blows directly upon it." The outer edge is totally unlike that of the Low Isles reef. Not merely is there no small debris of the kind that makes ramparts, but there are only very occasionally any boulders thrown up by the surf. Instead of the gently declining, bare outer rock face of the reef that was familiar to us, there was a parapet-like edge forming a summit to a steep slope, all covered by vigorous living coral. At an extreme low tide this outer ridge would, technically speaking, just dry: that is to say, although every breaker sent a seething tide over it, by taking courage and a firm stance, one could place oneself at this ultimate limit of the continent's intrusion into the ocean and watch the great seas gather themselves together and rise to form prodigious curling breakers. Just before the crest crashed on to the reef, there would be seen through the prism of blue sea water a shifting pattern of red, brown, and green, the refracted image of the living coral of the reef face.

At the southern end of Yonge Reef this ridge was regular and unbroken, but in the northern part, and in the other reefs of the same class that we visited, there were occasional dentellations forming deep gulfs into the outer line of the reef (Plate 12), very much as if the sea had broken down this ridge defence of the outer moat (described below).

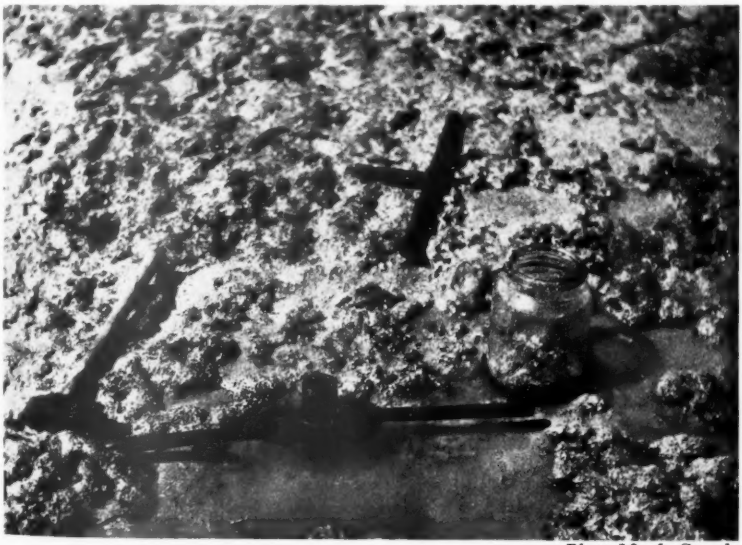
In the ordinary way the ridge formed a solid wall to the outer moat topped by a parapet of corals. The corals of the ridge would only be a few inches higher than the great blocks in the moat, but the difference in level was enough to be easily visible when defined by water.

At low water of an extremely low tide there was 100 yards of shallow water described as moat between the outer ridge and the reef crest, which was the principal drying area of the reef (Plate 14). The reef crest was of a smooth-surfaced rock covered with a thin veneer of a pink nullipore: its surface sloped very gently downwards towards the outer ridge below the water of the moat. There were few corals in the shallow water of the moat near the reef crest, but as the water deepened they became more frequent. Just before the ridge was reached more space was taken by the coral than was left vacant. Quantities of living coral grew on masses of dead material, and the floor dropped more rapidly until the pools and crevasses were about 5 feet deep. The outer ridge beyond this represented the consolidation of these rock masses.

There was an interesting zone at the inner edge of the moat where the water was about 6 inches deep. In it there were no living corals or seaweeds of any account, but numerous long-spined echinoids which bored holes to live in some

Phot. M. A. Spender

15. Rocky reef face outside rampart at weather side of reef



Phot. M. A. Spender

16. The third bore, Low Isles: in honeycomb rock

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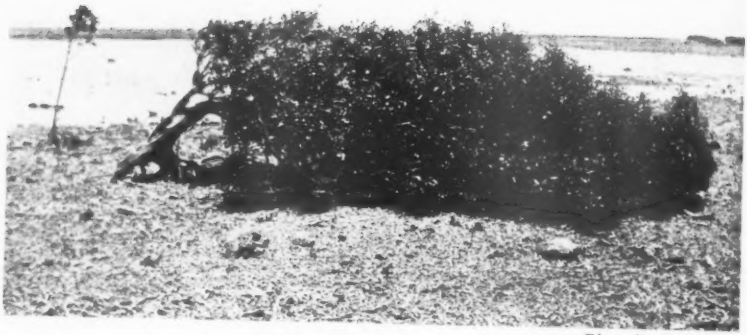


17. The mangrove Avicennia *Phot. J. S. Colman*

Phot. M. A. Spender

18. North-west bay of Lizard Island, showing camp and launch "Tivoli"

4 inches deep and ½ inch in diameter. They were as frequent as approximately six to the square foot, forming a zone 15 or so yards wide by some miles long, and pretty destructive to the reef.

The reef crest had a smooth rock surface from which grew a few corals, mainly brackets of Acropora*; there were no pools in this zone and the coral colonization was rather sparse, save for an occasional clump of a particular acropora, *A. hebes*, at the summit of the crest. This form of coral growth, apart from any other evidence, would indicate that the reef crest is uncovered at spring tides only. Even so there was considerable mortality among the coral exposed to the sun during those four or five days of fine weather at the spring tides of June 1929. But the most striking fact about the reef crest is the entire absence of debris: on it there are neither boulders, dead corals, nor shingle fragments.

The debris that is thrown on the reef forms a boulder zone parallel to the reef crest and frequently separated from it by a moat. The drying part of the reef crest is about 150 yards wide: its surface slopes downwards and inwards, in the same way as outwards, to a narrow inner moat, about 50 yards wide, beyond which is the accumulation of boulders.

The inner moat has a rough rocky bottom. There is a good deal of living coral, and where loose material occurs it is thickly encrusted with a nullipore growth and frequently cemented to the floor.

In the boulder zone, fairly large rocks, shingle, a few shells, and sand are distributed haphazard, so that between piles of boulders there are pools with a sandy bottom containing a fine growth of living coral. Though the boulders are nullipore-encrusted, they are almost all free to move. The whole zone is extensive, being about 250 yards from inner moat to its western, or inwards, limit; beyond this there is no more reef that dries properly, although a quantity of living coral can be seen projecting above the sea. Such a profusion of coral is rarely seen elsewhere. The colours are brighter and the corals larger than at Low Isles. The exceptionally clear water allows the light to penetrate and be reflected from the sand at the bottom, so that the sea is illuminated to a beautiful pale green, and the coral and many fantastic fish are visible to a depth of about 5 fathoms. With deeper water the areas of coral become more dispersed and it becomes possible to navigate a launch between the large coral-heads and patches. These rise almost vertically from the bottom to flat, table-like surfaces of coral rock, on which are scattered living colonies, which are often surprisingly scarce. These patches are very extensive in the lee of some reefs.

The outer barrier reefs, following the trend of the Queensland coast, generally run more or less north and south. None therefore expose a broadside to the full force of the Pacific surf, since the Trade strikes all obliquely. The axis of Yonge Reef runs north-north-west and south-south-east, and hence the reef is not as fully exposed as some. We have taken it as an outer barrier archetype on the evidence of Ruby Reef and Escape Reef, which, it should be remembered, are rather more protected, Ruby Reef by Andersen Reef, and Escape Reef by lying half a mile within the 100-fathom line. Though in these reefs the same assembly of zones was not present, we were able to use the same

*In the absence of agreement amongst zoologists as to the employment of the word "Acropora" or "Madrepora" I accept Professor Stanley Gardiner's ruling.

terminology, and that, as will be seen later, is not possible in the case of an "inner" reef.

Ruby Reef had a reef crest which was of a rough rock covered with a layer of algae and sand: in some places the foundation of the reef-crest was friable; there were a number of boulders and dead coral colonies on its surface. Inner moat, boulder zone, and anchorage coral were run together to form a rather confused zone. In Escape Reef, the reef crest was intermediate in type between Yonge Reef and Ruby Reef. The rock was not so smooth nor the lithothamnion growth so strong as on Yonge Reef; but there were not as many boulders, nor as much algal growth with the attached coating of sand as at Ruby Reef. Each showed outer ridge and moat with the same dominant corals on these zones and on the reef crest.

The normal inner reef is disappointingly amorphous and has a poor display of coral. In those reefs of which we know anything, no suggestion of an outer ridge or moat has been seen. At the weather face of the reef there is a rocky, gently graded slope on which some large boulders are scattered. The living coral is not profuse, which distinguishes it from an outer reef, and there is no suggestion of a rampart, which distinguishes it from an island-reef. As soon as the outer face has reached its highest point, which is not far from the breakers, there is an immediate transition to a surface very like the "thalamita" flat of Low Isles. That is to say, there is a great deal of sand on which lie many small boulders most of which are like pavement slabs of dead coral rock. Such coral as occurs on the reef-flat tends to grow in the many pools rather than from the reef surface, as on the outer reefs. An abundance of algae grow in the sand, especially where the flat, sloping gently down to leeward, is always covered by a shallow protecting layer of water. It is Mr. Tandy's opinion that the alga *Caulerpa* plays a very important part in binding the sand on Batt Reef, vast and sand-covered, east of Low Isles.

The various points of resemblance and difference between these three types —viz. the outer reef, the inner reef, and the island-reef (not a final classification)—provoke many questions: some of these are raised by any coral reef, but often overlooked; others are peculiar to the Barrier, and these we shall take first.

The importance of the shingle-rampart on an island-reef was so much stressed in Parts I and II of this paper that the rampart was all but singled out as the distinguishing characteristic. Now an inner reef and an island-reef are in the same environment. The wind, seas, and tides that affect one affect the other. There are island-reefs with as much shelter as most inner reefs obtain from having another member of the same series a little way to windward, and there are inner reefs as exposed to the weather as most of the island-reefs by virtue of their isolation. The supply of shingle for the ramparts is from below datum and it is hardly possible that the coral responsible should be affected by the type of reef on which it may be growing, provided it is always below the sea. If ramparts were merely a probability, a matter of chance, reefs with and without them would be distributed over the area of the protected seas entirely at random. The same reasoning would be applicable, I am inclined to think, if a reef's age of itself, that is apart from any other incidental events during the time of its existence, decided whether or not ramparts should be formed.

These external arguments support the belief that unless the reef flat attains a certain, possibly critical, level above datum, no rampart will be formed. The internal corroboration of this is that the flat of Low Isles is as much as 4 feet above datum (low-water springs), and so far as is known this is also in agreement with the flats of the other reefs of this type. The inner reefs, on the other hand, do not uncover so early on the ebb; moreover, a comparison between the living population of the two areas indicates the Low Isles flat to be materially higher.

An attempt was made to obtain direct evidence on this important point. But it is not an easy matter to find mean sea-level at an open reef. A recording tide-gauge has to be set up in an exposed position, which is a full-sized engineering job. Amongst our equipment was a gauge by Messrs. Richard Frères of Paris working on the principle of a barograph. An experimental tripod made to support the mechanism which was light enough to be carried by the launch *Luana*, the only transport available, was unfortunately too flimsy for the sea, which during an experimental run playfully bowled it over at high water one morning, damaging the works irreparably.

The relation between the level of the flat and the form of the debris accumulation on the reef gives a method of classifying the reefs and brings the whole variety found between shore and barrier into the scope of a single idea. Of the debris forms, sand-cays are the most conspicuous; they are distributed much more freely than ramparts. Most of the inner reefs have cays. Some of these are vegetated stable structures, with much sand-rock about their footings suggesting antiquity. Where, as at Green Island (see Plate 4 of Mr. Steers' paper), coconuts have been planted, a charming South Sea effect is produced. Other cays, less secure, have their vegetation occasionally obliterated. The cay of Pickersgill Reef is an example of one described (*Austr. Pilot.*, vol. iv, p. 225) as slightly vegetated, but which at the time we visited it was nothing but a bare bank of sand.

There are no cays on the outer barrier of the subsection of the system between the latitudes of Lizard Island and Low Isles. Three occur however in the latitude of Cape Melville, and there are three more to the north. On the whole they are improbable on an outer reef.

Considering the reefs as a whole, they may be classified according to the form of the debris on their surfaces thus:

Class I.—Those reefs where the debris is scattered over the surface without forming a cay or a rampart. Yonge Reef, all the outer barrier reefs we visited, and, so far as is known, the majority of the outer barrier series fall into this class, together with a few of the inner reefs.

Class II.—Reefs bearing a sand-cay but no rampart. A few outer reefs and nearly all the inner reefs belong to this class.

Class III.—Reefs having sand-cay (immaterial whether or not vegetated) and rampart, but no vegetation on the rampart or flat. Since postulating this type of reef I have found a reference to one example. The unique case is "B" reef,* not far from the Hope Isles, and one of the reefs in the steamer channel exceptional in that it is not an "island-reef."

Class IV.—Reefs having sand-cay and ramparts; the ramparts vegetated,

*Taylor, T. G., and Hedley, C., "Coral Reefs of the Great Barrier . . .," *Reps. Aust. Ass. Adv. Sci.*, 11, 1907, p. 402.

but no distinctive vegetation of the flat such as the mangrove Rhizophora. None of this class known in the Barrier Reef region.

Class V.—Reefs having sand-cay, vegetated rampart, and mangrove swamp on the flat. These are the island-reefs of Parts I and II of this paper.

This classification summarizes the ideas of this paper. The sequence is deliberate and presents a series of characteristic forms assumed by the debris corresponding with increasing height of the reef flat. That the outer barrier reefs rarely support a sand-cay is due to the low level of the reefs, rather than to the extreme exposure to wind and weather. In other parts of the world there are barrier reefs having sandbanks and islands on their surfaces: the reefs of the Spermonde archipelago* have a completely indiscriminate distribution of sandbanks and islands over barrier and inner reefs alike; while in almost the same latitude as this part of the Barrier Reef there are the Society Islands where sand islands have formed on the barrier reefs in the most exposed positions.

The differentiation between inner-reef and island-reef is again a matter of level. It is supposed that a cay can exist on reefs lower than those on which a rampart can be formed; according to these ideas it is inconceivable that a rampart should exist on a reef where already no cay is found.

Once the more mechanical features of the island, the cay and ramparts, are established, the development of the vegetation depends on the available plants suitable to the levels and the special conditions of the climate. Judging by Dr. Umbgrove's account of the coral islands of the Java Sea,† and such other information as is accessible, the population of the rampart by a tree like the mangrove Avicennia is altogether more likely than the succeeding formation of the swamp on the flat. Whereas the first appears to be possible where the monsoon reverses direction during the year, the rhizophoretum or mangrove swamp of the island-reefs may be conditioned by the exceptional circumstance of the Queensland coast, where the rainy season is accompanied by no monsoonal wind.

The principal problem is now transferred to that of the level of the reefs. If a reef were to grow persistently upward, the successive appearances would follow our schedule, which would then become a chronological sequence. But after examining the outer reefs we concluded that while the surface can still support some living coral, the form of the growth and the absence of debris almost rule out the possibility of any increase in height by simple growth. The inner reefs, so far as the present purposes are concerned, were almost lifeless. Sand and debris were scattered to a great extent, but at present our knowledge of the processes by which these materials are compacted is so meagre that it is not possible to state definitely whether or not the reef flat is being built upwards. My own opinion is that the inner reefs have reached the limit of upward growth in sheltered water.

By this reasoning the island-reefs have been formed by the slight emergence of reefs resembling normal inner reefs. Their principal feature, the rampart, depends on the existence of a flat higher than an inner reef, abnormally high

*Umbgrove, J. H. F., *Leidsche Geol. Med.*, iii, 227–247 (1930).

†Umbgrove, J. H. F., "De Koraalriffen in de Baai van Batavia." Dienst van den Mijnbouw in Nederlandsch-Indië. *Wetens. Med.*, No. 7, 1928, and "De Koraalriffen der Duizend-Eilanden (Java-zee)." *Ibid.*, No. 12, 1929.

therefore. We have already argued that the conditions experienced by either reef are identical, and that the only differentiating factor to account for the presence of a rampart on the island-reefs alone, that is on the reefs in the steamer channel, is the level of the flat. The slight emergence here postulated is of the same order as the smaller of the two elevations claimed by Mr. Steers. Mr. Steers drew attention to two wave-cut benches on the mainland representing emergences of about 8 and 2 feet respectively. On any reef that we have seen in this portion of the Barrier, that is between 14° 30′ and 16° 30′ S., there is no surviving indication of an 8-foot emergence. But the smaller elevation, between 1 and 2 feet, is of the order required to cause the formation of an island-reef on the surface of a normal inner reef. The corollary is properly applicable: that the existence of reefs of Classes III–V is itself evidence of a slight emergence.

The amount of emergence decreases from the coast towards the Pacific. The evidence of the coastal physiography presented by Mr. Steers in his paper points very strongly to a small recent uplift, affecting the coast-line along the entire length of the region examined. This uplift or emergence is in evidence, by our reasoning, in the island-reefs, which form the series of reefs first met with after leaving the mainland. But the inner reefs, to seaward of the island-reefs and the steamer channel, do not bear out this uplift, nor do the outer reefs of the barrier series.

There are one or two other points of distinction between the reefs on which the island-reefs have formed, and those of the inner series. They tend to be smaller: an inner reef has leading dimensions usually exceeding 1 mile, which is often the length of the longer axis of an island-reef. They are not associated with the zone of coral heads and reef patches which stretches to leeward of the greater number of the inner reefs. In fact, the direct indication of the work done below sea-level by the shore party on Low Isles was that at present the conditions at the bottom of the sea are unfavourable or prohibitive to colonization by coral. In the neighbourhood of Low Isles the sea-bottom is very muddy: frequently the water is stirred up from top to bottom and becomes very opaque (see Boat Party reports). The conditions contrast strongly with those that prevail at present near Lizard Island, where from the top of the mountain on a clear day a maze of brown and emerald green patches representing coral reefs of every degree and variety can be seen dispersed in every direction over the blue plain below. Stormy weather of the kind that made our departure from Lizard Island an adventure barely changed the colour of the sea in the neighbourhood.

There is then a possibility that the island-reefs belong in a geological sense to a different order of coral reefs from those of the inner series. The results of the borings into the reef on Low Isles are so anomalous that something abnormal, even for a coral reef, is suggested.

At the very end of our stay on Low Isles, Mr. Orr, Mr. Nicholls, and myself had some time free from our proper lines of work, and it became possible to make bores at three different positions on the reef. The equipment had been lent to the geographical party of the expedition by Sir Edgeworth David, who had himself used such a set of hand tools during the war to find water for the

troops. Mr. Marchant and myself, assisted by a great many volunteers, had previously put down the casing into the centre of the sand-cay, to try out the plant and to settle the question of whether there was cemented sand-rock under the middle of the cay continuous with the outcrops on the beach. We reached datum-level, encountering nothing but sand similar to that at the surface. It was interesting to find that in all probability there is no cementation in the interior of the cay; but the more important consequence of the experiment in view of what happened later was that the labour was so heavy and progress so slow in sand, that I decided that time was more profitably employed completing the survey than in attempting, short-handed as we were, to bore the rock of the reef.

Briefly, the results were as follows: The first bore was in the sand-flat opposite the cay. After a zone of sand down to 5 feet there was an abrupt change to a soft clean grey mud, through which the tool passed down quite easily from 5 to 15 feet below the surface. The next day another bore was put down in the mangrove swamp where it might be more likely to pierce a part of the reef flat than any ancient sediment bank under the lee of the reef, whatever that might be. Here there were 18 inches of soft brown mud for which the mangroves themselves may be held responsible; this was followed by 6 inches of a kind of peat of mangrove bark, etc., 2 feet of sand, and then clean grey mud resembling, but more sandy than, that of the first bore, for as far as the tool would probe, about 15 feet.

Having twice failed to find a solid sub-stratum to the reef, a position was chosen for the third attempt on a part of the reef that seemed more solid than any other part of the flat. Near C beacon, a few yards within the rampart, is a hard smooth rocky platform or pavement that seemed as much likely to be integral with the reef itself as anything (Plate 16). The first 18 inches were laborious enough: with crowbar and hammer and chisel the rock was broken up, showing it to be a cemented formation of coral fragments similar to those which form the rampart. At 18 inches the tool slipped through, quite suddenly and dramatically, into the now familiar soft grey mud.

These results, which will be completely described elsewhere,* are presented here without comment: they are very baffling, like so many reef borings. The definition of a coral reef becomes more difficult as these unaccommodating facts are revealed. There is a likeable trace of bitterness in Jukes' "A coral reef is a mass of brute matter."† Vaughan described a reef as "predominantly composed of calcium carbonate, secreted by organisms, of which the most important are corals."‡ Professor Skeats points out that this position is not tenable. "The careful, precise and monumental work of Dr. Hinde on the material from the borings at Funafuti . . . [shows] . . . that in the upper 180 feet of the boring, whose coral reef origin no one has questioned, about one-fifth of the organisms consisted of corals, the remainder consisting of calcareous algae, foraminifera and other organisms."§ In the third boring through the reef rock pavement

*Reps. Gt. Barrier Reef Expedition. London. Vol. i. "Sedimentation on Low Isles reef and its relation to coral growth." S. M. Marshall & A. P. Orr (in press).

†*Loc. cit.*, p. 316.

‡Annual Rep. Smith. Inst., 1917 (230, 231).

§*Amer. J. Sci.*, Ser. 4, vol. 45, 1918, pp. 81–96.

at Low Isles a few feet below the surface only two-thirds of the mud was calcareous.

Of Funafuti it was written: "So far as the structure of Funafuti has been proved by borings, it is scarcely what a field geologist might have anticipated, and if deposits of a similar nature and origin had been encountered in, say, the Mountain Limestone, it is doubtful whether, previous to the borings in Funafuti, their interpretation would have been easily reached."* When, fully conversant with the Funafuti experience, they bored at Michaelmas Reef, they reported: "The boring results were somewhat unexpected, as far as the character of the coralline material was concerned and in regard to the underlying material."† Our shallow probings were made on a reef only 50 miles or so from Michaelmas reef: of the results, Mr. Orr, who is responsible for their publication, writes: "The general presence of a cap of sand or rock overlying a considerable depth of soft mud is, to say the least, unexpected."

During a discussion between Dr. Umbgrove and myself about some of these points of reef formation we gradually exposed the difference between the structure of those reefs with which he was most familiar, the reefs in the Bay of Batavia, and those which seemed at first sight to resemble them so closely, the island-reefs of the Queensland coast. In his examples the sand of the cay extended to the mud bottom of the bay. There was no such thing as a rocky reef face under the lee of the islands; and the cay therefore could not be described as lying on the reef-flat. Nor was there an exposed rock face at the weather side of the island: rather it seemed likely that the talus bank of rampart material extended well below sea-level. The many excellent air photographs he has published confirm these points as well as stressing the obvious differences of proportion. Reef-flat as we know it hardly exists. A strip of something larger than a moat, but too small to be called a reef-flat, flooded and populated with our moat coral, *Montipora ramosa*, occurs between the large cay and the irregular shingle rampart; its width is small compared with the dimensions of the cay. Here, in the features as well as in the proportions, there was evidence that the building of these islands takes place in a comparatively simple way as a continuous and progressive process; the assumed structure is illustrated in the block diagram, Fig. 17, of Dr. Umbgrove's account.‡ The windward structure is mainly a bank of coarse fragments (rampart shingle), overlying the original rocky matrix of the reef. At the leeward side of the formation a gradual accumulation of sand takes place, forming a "sand-plate" (which I take to be a sand-flat) and which eventually emerges as a cay, a moat being left between this and the rampart. The moat is maintained at a uniform depth in some such way as that suggested by Mayor in his article on "Causes which produce stable conditions in the depths of the floors of Pacific fringing reef-flats,"§ where the control is by the current of water running off the reef-flat.‖

*W. J. Sollas in the special Royal Society Publication, London, 1904.

†Reps. Gt. Barrier Reef Com., vol. ii, Brisbane, 1928, Introduction.

‡"De Koraalriffen in de Baai van Batavia." Dienst van den Mijnbouw in Nederlandsch-Indië. *Wetens Med.*, No. 7, 1928.

§No. 340, Papers from the Department of Marine Biology of the Carnegie Institution, vol. xix, 1924.

‖See also Mr. Orr's work on the moats of Low Isles.

This divergence of form and structure, confirmed by the borings on the islands Onrust, Kuiper, and Edam, between the two groups of reefs of considerable superficial resemblance, is important. In the case of the reefs of the Bay of Batavia, one can, from the evidence of the reefs themselves, speak of the development of all towards an easily defined final form. In this the cay is large enough to cover almost the whole reef, is well wooded, and is in contact with the shingle rampart; the Island Alkmaar is an example of the mature form. A similar island development has been described from the Thousand Islands (Java Sea) and the Spermonde Archipelago (S. Celebes).* There is more than a temptation to take it as self-evident that the island-reefs of the Queensland coast tend to develop towards an island where the mangroves cover the entire space between the rampart and the cay—a different end term from that above. But the evidence of the reefs I take to be otherwise. The relics of previous movements seen in the sand-rock, conglomerates, and occasional dead or dying mangroves, the limits of the mangrove-swamp, and also the historical evidence, all suggest that the islands have existed long enough to find an equilibrium of the elements on the reef, about which distribution alternate growth and destruction make small oscillations. Thus the narrow belt of mangroves on the Ingram-Beanley reef (lat. 14° 25′ S.) is not necessarily a less advanced stage than, say, Three Isles. Nor should the colonization of Three Isles be taken to be a less mature form than Low Wooded Island, 3 miles distant. Each has reached for the given form of the reef and weather conditions a comparatively stable and balanced finality. A century ago at Low Isles there appears to have been an additional mangrove colony, probably not very large, at one of the shingle tongues at the south of the reef; the position is now marked by a few battered and ancient Rhizophora trees. Although the main colony appears to be at present in a phase of extension towards the west, across the "mangrove park" this additional islet has to all intents and purposes been obliterated. Perhaps the deep pools in the present mangrove park mark where a former westward extension of the mangroves has broken up by the acid decomposition products the cemented reef formation, for we may take it that the mangroves are able to "dig themselves in" to the reef by breaking down its cemented surface.

There is still a great deal of information to be obtained from the measurement and examination of the surface features of coral reefs; as more results become available comparisons perhaps more valuable than individual accounts will be possible. It seems that shallow boring, mapping, and levelling could with advantage be carried out to a considerable extent before another deep boring is made, and that a more complete knowledge of reef structures and reef processes is necessary before the world problem as expressed in such a phrase as "The Problem of Coral Reefs" can be adequately treated—if, indeed, such a phrase should be found to have any meaning.

This account is patently not the product of the efforts of a single-handed surveyor. The acknowledgments I have to make are for the most part for something more than help: more often than not, the possibility of carrying out a piece of work depended completely on the assistance that was forthcoming.

*Umbgrove, J. H. F., *Leidsche Geol. Med.*, iii, 227–247 (1930), and Dienst van den Mijnbouw in Nederlandsch-Indië. *Wetens. Med.*, No. 12, 1929.

Mr. George Butler's services to the scientific investigation of the Great Barrier Reef have already received comment in the literature of the subject.* He owned the *Tivoli* and was with us both in the first three months' cruise with Mr. Steers, and later when the programme of work on the outer barrier was carried out from Lizard Island. Other seamen have regarded coral reefs as obstacles and dangers, but Mr. Butler always accepted them as if they were placed there to provide shelter for small boats in troubled waters. He could recognize the break on a reef 4 miles distant, and close amongst the coral could thread a passage through the coral heads right into the eye of the sun. These abilities were combined with an exceptional knowledge of bush-lore: without him, a very great deal would have been impossible. In the work of the survey I was assisted for a short time by Mr. E. C. Marchant, from Cambridge. For four months Mrs. Stephenson undertook the unexciting labours of a surveyor's assistant and did a large part of the work in the survey of Three Isles. I have drawn freely on the work of other members of the shore party, notably Dr. Stephenson and Miss Manton: the shore party tackled the reef survey as a team and pooled their results at the end of each day's work. Mr. Tandy, botanist, of the British Museum, was the absent member of the shore party while I was at Low Isles: I have reason to be most grateful to him for his helpful and constructive, if austere, criticisms of this paper while it was being written. Mr. Steers, Professor Stanley Gardiner, Dr. Umbgrove, Dr. Yonge, Mr. Orr have all helped with the draft; there are others, too, who must go unnamed, to whom I am none the less grateful.

APPENDIX II: A NOTE ON THE APPEARANCE OF CORAL REEFS AND NAVIGATION AMONGST THEM

The Admiralty Pilot Books give in one or two cases a short paragraph on the appearance of coral reefs. The information is for those in charge of steamers which do not often work among reefs, although it is not qualified by any account of the way the appearance may alter with changes of weather conditions. These notes are based on experience in working amongst the reefs of the Barrier Reef in a small boat—a 50-foot launch—and apart from their general interest might be of assistance to a navigator intending to cruise in reef-strewn waters.

In fine weather—a slight ruffle of breeze, a clear sky, and a high sun—reefs can be seen as they are described in the Pilot Book. Surface reefs, reefs almost awash, are a brilliant yellow brown; those covered by about 2 fathoms, a bright green; and I have seen shoals as deep as 8 fathoms as a blue green easily contrasting with the indigo of the deep water. A completely inexpert observer would have no difficulty in conning his ship with absolute safety under these conditions. Even the purple shadow of an occasional cloud, which can be so confusing at other times, could not deceive him.

It should never be taken for granted however that reefs are going to be seen without difficulty: that they are so obvious under ideal conditions is to a certain extent misleading. Reefs occur in those parts of the world where there are also calms and Trade winds. On account of its false sense of security, a glassy calm is a highly dangerous condition: the glare on the water makes it impossible to

Proc. Linn. Soc., N.S.W., vol. 27, 1902, p. 147.

see coral, be it ever so close to the ship, and it is consistently difficult to convince oneself of this fact. With the Trade however there is a complete change of conditions. There is nearly always much cloud, and this has three important effects. There may not be direct sunlight shining on to the reef, there is much cloud reflection on the water, and the sea is strewn with cloud shadows. Given a rough sea and turbid water (a wind of more than force 4 will stir up the bottom from 20 fathoms) to complete the change and it will be hardly surprising that the appearance of coral is entirely different.

There may be a good line of breakers marking the outer edge of some reef systems, but in the protected waters there will be nothing but a confused interplay of light and colour. The lighter cloud reflections can generally be distinguished at once. There is so much reflected light that reef tends to appear darker than the surrounding water. Under these conditions it is frequently difficult to distinguish between heavy cloud shadow and reef, and in any case of doubt one must assume danger and put the ship about. The motion relative to the ship is the best criterion; the cloud shadow will probably be moving at about 20 knots over the sea. (It is advisable not to wear tinted glasses.) With a little experience one becomes able to pick out the stationary reef-patches even though they can hardly be seen by any colour contrast. But given much cloud, a normal Trade wind, and a full tide over the reefs, and any indications apart from the break are very slight and every conceivable precaution must be taken.

Generally speaking, a look-out is continuously necessary in the vicinity of reefs; and the mast-head, though it can be very uncomfortable in small craft, is the place for him. "The commander . . . must not, however, be one who throws his ship's head round in a hurry, so soon as breakers are announced from aloft: if he do not feel his nerves strong enough to thread the needle, as it is called, among the reefs, whilst he directs steerage from the masthead, I would strongly advise him not to approach this part of New South Wales."* Quite small increases in the height of the eye make large differences to the facility with which reefs may be seen. Mr. Butler could often see a break 3 miles distant from as low a position as 25 feet above the water-line. It is naturally very important to have simple methods of communication between look-out and helmsman; easily grasped signs with the hand are better than any attempt to sing out orders. One cannot work towards a low sun: this must be remembered in planning out a day's work. When the sun has reached about 45° of altitude a practised eye can take a vessel within 4 points of the glare.

When working among reefs one rarely has a chart as authoritative as familiar coastal sheets. Difficult sea conditions and inadequate marks in the neighbourhood make reefs awkward to survey. Especially is the shape of a reef likely to be charted in a misleading way. The reef convention is variously interpreted by hydrographers. Some extend it to cover the zone of detached portions of a reef, for instance, where others would use a sign for rocks at low water. Small craft cannot rely on the charted shape for indication as to where anchorage or shelter may be obtained. Particularly are the occasional anchor signs valueless: they seem merely to indicate that the survey vessel found such a place to be a tolerable anchorage, so they fixed it.

In the Barrier Reef region the mainland was high and well charted. Visi-

*Flinders, M. *Loc. cit.*, vol. ii, p. 104.

bilities of as much as 50 miles were obtained quite frequently, but the Trade wind is almost always accompanied by what seems to be a dust-haze, which usually reduced visibility to about 10 miles, sometimes more, sometimes less. On one exceptional occasion, when quantities of dust were deposited on decks and rigging, visibility was cut down to a mile or less and several meteorological stations made their first record of fog.

In this kind of work positions when they are needed will probably be for points of departure, successive reefs being used as departures later on. A fix made from mainland observations will be of little use among reefs except it be precise, for if a wrong departure be taken, a sequence of reefs consistently incorrectly identified may be misleading enough to put the vessel into danger before the error is discovered. In small craft, sailing boats, launches, etc., compass bearings hardly ever give a good enough position. Even if small compasses have no errors in their operation, the motion makes it impossible to use them properly. A sextant and station pointer however can be employed under quite disagreeable conditions. Particularly, it is well to have some idea of the drift or errors of a course before losing the land on a run out to sea; neglect to take this precaution was once the cause of a vessel having to approach a reef from a bad angle, and actually touching coral.

Moreover, compass courses in small craft are at the best only roughly accurate. It would be unreasonable, for instance, to expect to "make" a passage opening, say half a mile wide, at the end of a run of 6 miles, absurd as it may appear to the navigator of larger craft. It is better to steer deliberately for the reef, either so that the break on the weather side be visible, or the sun be well placed behind the look-out, so that the vessel can be worked along the reef edge. Otherwise one may not know on which side of the opening one has erred at the end of the inaccurate compass course.

When steering amongst dangers the general rule, always to keep danger in sight—in other words to work with short departures—is strongly to be stressed. It is rash in the extreme to steer broadly down the middle of a channel, hopefully thinking that all is safe. A mast-head man, carefully following close to the edge of a reef, can tell at once if the visibility of reefs changes and coral tends to become dangerously invisible. If courses are made from reef to reef, the navigator always has a good idea of his position and a mast-head man of the conditions.

It is not difficult to acquire a sense of security in working amongst coral. Once acquired, a district unsurveyed and marked as full of dangers is attempted with as much confidence as more familiar waters. In fact, what has to be remembered is that the familiar area must always be navigated with as much care as if it were being entered for the first time. Though coral is rightly regarded as a danger, it need not be inferred that the occurrence of reefs implies dangerous conditions. With skill, the reverse is true. The reefs are magnificent breakwaters, and in hard weather, making use of the shelter they provide, passages can be made in comfort and safety, dodging from reef to reef, that would be miserable, or even impracticable, for a small vessel in the open water away from the reefs.

DISCUSSION

Before the paper the PRESIDENT (Colonel Sir CHARLES CLOSE) said: To-night we are to listen to a lecture, anticipated with a good deal of pleasure, by Mr. Spender, who went out with Mr. Steers to the Great Barrier Reef. Incidentally, I notice that in the *Journal* the title is "Further Work on the Great Barrier Reefs," and I wonder whether, in future, we are to use the plural. Mr. Spender was attached by the Society as a geographer, with Mr. Steers, to the expedition that went out to explore, particularly biologically, that very remarkable feature of the Earth's surface. When Mr. Steers came home Mr. Spender remained on the Reef, and he was there for about a year. The difficulty experienced with regard to transport resulted in his confining his surveys and investigations mainly to two islands. That was perhaps rather fortunate, for what we required, undoubtedly, was an intensive investigation. I understand that Mr. Spender's work and that of Mr. Steers will be quite fundamental in the future for the study of reefs. I think, in fact, it will be found that the text-books on the subject will have to be largely re-written, perhaps in a more cautious direction. I ask Mr. Spender to tell us the result of his investigations.

Mr. Spender then read an abstract of the paper printed above, and a discussion followed.

Sir MATTHEW NATHAN: In the presence of so many experts, both geographical and biological, I shall make my remarks few, brief, and general. One thing that must have struck those who have listened to the lecture to-night and who heard Mr. Steers a few months back is the number of other sciences with which geography is closely associated so that it may indeed be called the mother of sciences. We heard a short while ago a lecture with regard to this part of the Earth based on geology; we have listened this evening to one closely associated with biology; and last year, in connection with Captain Cook's adventure on this same Barrier Reef, we had geography giving rise to history. From its geographical conditions arises also the economic value of the Reef.

As regards the special points of the lecture this evening I feel I shall have to sit for some time in front of those three diagrams based on the survey of the south-east corner of Low Islands, of Three Isles, and of Western Hope Island before I understand how closely analogous features have been created in all three; or rather, I should have to make that study if it were not that I am sure the lecturer of this evening will produce further results from his own work which will make the matter quite clear to us.

Referring to a minor detail of the lecture I am sure many present were greatly interested to hear an explanation of what we call "nigger-heads," those great blocks of coral thrown on to the surface of low islands in coral seas. In one of the volumes published by the Great Barrier Reef Committee of Australia there is a paper by the late Dr. Paradice containing a careful study of these mushroom growths, though I do not remember that he gave the same explanation as Mr. Spender to account for the detached coral so often having grown like a pyramid standing on its apex, viz. that in the range between the tides conditions of growth are more favourable and that the expanding growth at the top makes the block top-heavy and so liable to break off. The mushroom nature of the growth is however an old discovery first published by Professor Dana in his book on 'Corals and Coral Islands,' in an account of the reefs of the Abrothos of Brazil.

There are many other features of the lecture this evening which will give us thought, thought which will be aided, I am sure, by the views of the experts that will follow these few halting remarks of mine.

The AGENT-GENERAL FOR QUEENSLAND (Mr. E. H. MACARTNEY): This great

undertaking on the Barrier Reef has been Sir Matthew Nathan's interest for quite a number of years past, and he more than any other man is entitled to credit for having brought about the scientific investigation that has recently been made and with such successful results. I believe that those results will be of benefit to Queensland. While I cannot contribute to the expert discussion I shall be glad to show to any one who cares to visit the Queensland offices in the Strand specimens of coral which have recently been sent from Queensland of a most beautiful type and colour. You can see the coral just as it appears under the water on the Barrier Reef.

Mr. J. A. STEERS: I would like to congratulate Mr. Spender very much upon the clear way in which he has put his points with regard to the low wooded islands. He has told you, more or less, where we went in our cruise in Barrier Reef waters, and although we saw many points of very great interest, I think we both agreed that the most interesting were the low wooded islands and the cays. As he has made clear to you, the low wooded islands, of which Low Islands are a type, appeared to be characteristic of the reefs between the outer barrier proper and the mainland. So far as I know, there are none at all on the outer reefs, and in every case that we saw, with the exception of minor details, the same features occurred: a mangrove island, a sand cay, and outside the mangrove island the shingle ridges and the rampart which Mr. Spender has so ably described.

I regretted very much that my own time on the Barrier Reefs was so short that I was unable to help Mr. Spender to carry out further detailed surveys. Although circumstances allowed of his mapping in detail only two, or possibly three, islands—Low Islands, Three Isles and, to some extent, Hope Islands—I think you saw from his maps how extremely similar are their various features, and that they occur in just the same relative positions. I think he will agree with me that these features occur very similarly not only in those three islands, but in many more also, especially in the northern part of the Reef area. Further, several of those islands perhaps show, as he indicated, evidence of uplift. My own opinion is rather open on that point, although when I spoke about it before the Society in February I perhaps made it a little more definite than I ought to have done. There are, of course, evidences of certainly one, possibly two, elevations along the Queensland coast. There is a platform some 8 or 10 feet above present high-water level of neap tides, and the other, or lower, platform is somewhere about the actual level of high-water neap tides. Of course the level at which a platform is cut is a problem in itself, but certainly on some of the low-wooded islands the "promenade," of which Mr. Spender spoke, definitely suggests an uplift corresponding with the low platform of the mainland and high islands flush with high-water neaps. Further, as his pictures showed, that "promenade" is now definitely being cut into. It is however a problem on which a great deal more work is necessary before we can come to any very definite conclusion.

I would like to say how much I appreciate the excellence and the detail of the two maps he showed of Low Islands and Three Isles. Detailed maps of those two were, to my mind, essential, and I was very glad that he was able to get about a week on Three Isles in order to make a map there to compare with his map of Low Islands, the home of the expedition. I can only regret he was unable to do more.

I should like, in conclusion, to second what Mr. Spender said with regard to the excellence of Mr. Butler's help in our cruise.

Dr. STEPHENSON: As the member of the Barrier Reef expedition who was in charge of the ecological work which took place on the Reef I am pleased to be able to add another voice to Mr. Spender's with regard to one or two of the points raised in the lecture. I should like to emphasize particularly the point which he made when he said that a detailed survey of the kind which he undertook, involv-

ing a number of accurate measurements, is absolutely essential in any kind of reef work. After the completion of such a survey it is possible to return from the field of action, to work out one's data, and to form an accurate conception of the structure of the reef and of the inter-relation of its parts, both in the horizontal plane and as regards levels. If one makes simply a rough physiographical sketch of a reef, or a number of such sketches of many reefs, they represent one's initial personal impression of the reef gained, perhaps, on a brief visit; and, as experience with detailed surveys has shown, that first impression may be quite misleading. Another point which arises out of this is that in work on coral reefs the rigorous training which is imposed upon one in carrying out one's detailed surveys is quite necessary if one is to do general work on other reefs afterwards; in other words, a person with the training which has been gained from a detailed survey can go to other reefs after the one which has been surveyed in detail, and in quite a short time can appreciate their main features accurately. Any one who has not undergone this training may go to such a reef for a brief time and may carry away a completely wrong impression of its structure. For this reason I think Mr. Spender's work, which has been carried out with extraordinary persistence, thoroughness, and grasp of essentials, represents a very valuable contribution to the subject.

Finally, I should like to say that this is an instance in which cooperation between geography and biology is quite essential and is obviously beneficial to both sides. In carrying out ecological work it is obvious how the geographical side of things, the maps it is necessary to have, are of benefit to biology; but it is equally true that the biological side is beneficial to the geographer. It is found in practice, when working on reefs, that if one knows something of the plants and animals which live upon them, of their distribution and of the way in which they arrange themselves in zones with relation to the heights of the tide, it is then possible to appreciate much more readily the more subtle distinctions which appear in the physical features of the reef. On the other hand, it is quite possible to go on to a reef knowing nothing of its biology, and to miss some of these points altogether.

Professor STANLEY GARDINER (Secretary, Great Barrier Reef Committee): I should like to pay my tribute to the very excellent work which Mr. Spender has done and to the interest of the lecture he has given to-night. It is particularly valuable that he should have spent twelve months on those islands, and his recognition that very often seasons on coral reefs produce quite different topographical effects is valuable. I am afraid I am not an authority on coral islands, for I have never seen any island on any coral reef which is really like those shown, for coral reefs in general are not accustomed to having lagoon islands such as these, those which exist in the Maldives being of quite other formation.

There are a few points which struck one as being of great interest. In the first place, Mr. Spender drew attention to three borings. Mud formation is quite characteristic of certain reefs, usually to leeward. The water approaching the reef is acid; it is carrying a considerable quantity of carbonate of lime in it, and, when it gets to the reef, it finds plenty of fixed plants there and plenty of phytoplankton, and it is made alkaline. Can Mr. Spender tell us whether his mud is that usually associated with the leeward sides of reefs, which is due to precipitation of the carbonate of lime in solution, or whether it is mud which is formed by trituration of the fragments of the reef by organisms or whether it is due to bacterial action?

There is another point. This mud must form behind a rampart of some sort or other, and that rampart must be some stony material. May we deduce from the existence of this mud in three borings over this island that the island is becoming smaller rather than growing outwards? Certainly the whole account rather points

to a disappearing island, so far as the foundations are concerned, than to an island which is growing outwards or is in process of increase.

I should like further to emphasize what Mr. Spender, perhaps for the first time, has publicly drawn attention to, namely the vast difference between the Great Barrier Reef north and south of Cairns. He pointed out that the barrier against the sea north of Cairns is steep-to, which means that the 100-fathom line is within a cable or two of the edge of the reef; whereas south of Cairns the 100-fathom line is perhaps 5, 10, or 20 miles outside the outer line of the reefs. This suggests that in the problem of the formation of the Great Barrier Reef we have two problems: one north of Cairns and the other south, and that quite possibly we are dealing here not with one method of formation but with two modes: one to the north and another to the south. I would venture, if Mr. Spender would forgive me, to suggest that to the south we have a disappearing reef, not an out-growing reef, for every out-growing reef is steep-to outside, whether that reef be in the Maldives or the Carolines, or whatever group of islands you like to take in the centre part of the Pacific. I don't think that the southern part of the Great Barrier presents the facies of an out-growing reef. If this is so it is like the reefs off the western part of Australia where you have large coral structures, and in the western part of the Indian Ocean where you have reefs round Mauritius up to the Seychelles, which are disappearing reefs rather than growing reefs. A further series are found if we go to the Atlantic, viz. the not dissimilar reef formations off the Brazilian coast.

Mr. Spender emphasizes the differences between different parts of the Great Barrier Reef and has made it clear that he has views as to their causes. I trust that in his published account he will not restrict himself solely to facts but allow himself to speculate as to these. The breath of science is theory and the test of the same trial and error.

Mr. SPENDER: Professor Stanley Gardiner has raised points on which I am working at present: all controversial points on which I am not prepared to speak now without being in a position to marshal all the evidence; so that I shall have to refer him to the written paper. I will however recall the fact that where there is mud for the greater part of a boring 20 feet deep into these islands, there is often a fairly solid reef surface. It is really a very difficult problem.

The PRESIDENT: Before thanking Mr. Spender for his lecture I should like, for the credit of the Anglo-Saxon race, to explain that the word "Townsville" is not quite what it sounds. Mr. Spender has told me that Townsville was really named after a man called Towns, so it is not quite as bad as it seems. It is a very nice town, Mr. Spender says, and he was very glad to get there, but the name is less interesting, historically, than Cooktown. That place is, unfortunately, getting smaller.

The lecture we have listened to to-night has shown, as several speakers have said, how fruitful is the alliance between geographers and biologists. I hope that alliance will always continue. Mr. Spender has given a clear account of the admirable work he has done which has laid a foundation of accurate knowledge of the reefs. Discussions on coral reefs have, in the past, been too much a matter of hearsay or, as one speaker said, have resulted from very brief visits. But Mr. Spender spent a year on the Great Barrier and he really does know something about the subject; he certainly has advanced our knowledge of it. It is a subject which has almost a library to itself, and Mr. Spender has opened up a fresh aspect. I thank Mr. Spender, on your behalf and my own, for his admirable lecture.

DANAKIL TRAVERSED FROM SOUTH TO NORTH IN 1928

L. M. NESBITT

In June last year we published in the Journal a preliminary account of Mr. Nesbitt's expedition through Danakil in 1928, with a brief summary of his diaries which, together with his sketch-maps, panoramas, and photographs, had been deposited with the Society. We are now able to do greater justice to this pioneer expedition, and the following is a full account of the first part of the journey based directly on Mr. Nesbitt's daily entries in his diary, which were made throughout in English. With it are reproduced a number of the author's panoramas, sketched rapidly with a fountain pen on odd pages of his diary. The sketch-map reproduced here is merely a diagram published for convenience in following the broader outlines of the journey and to show the approximate points from which the sketches were made and their range. A more accurate map from Mr. Nesbitt's observations will be published with the second part of the paper.—ED. *G.J.*

ON 14 March 1928 I left Addis Ababa with two Italian companions, Signor Pastori, a prospector and trader, and Signor Rosina, a farmer from Eritrea. Travelling by car and train, we reached Awash Bridge Station, the starting-point of our journey, the same day. Here the Moslem Ramadan delayed us ten days, but on March 28 we finally got away. Travelling north-west, away from the river, we rested on the second day beside a swampy pool fed by a hot spring issuing from under a basalt cliff. Many doum palms grew round the spring and large numbers of cattle, camels, and goats watered there, and we saw many antelope at close range. That night we camped on a dry basalt plain dotted with occasional thorn trees and scanty grass, but next day we passed through more fertile country, where dense mimosas, intertwined in places by lianes, and grass sprouting up after the recent rains made the plain attractive. The fertility accounted for the herds of she camels, goats, cattle, and sheep. We passed several groups of huts, the Danakil women, slender and graceful, coming to the enclosures to watch us go by. At 11 a.m. we reached Wara Malka. From a distance the Halls's ruined house was visible, the only masonry structure since Awash station and hotel. As we approached, banana, orange, and mango trees greeted us. It was a treat to see all this green. There were enormous orange and lemon trees, the largest I have ever seen, also strange mangoes, coffee, kapok, and a silky plant, remains of a farming scheme since abandoned. That night I branded all the camels, having made the branding-iron myself in the morning.

At 9 a.m. on April 1 we left with a caravan of eleven men and twenty-one camels, three of which had been brought here. Travelling north-east we arrived at a ford, low and full of pebbles, over the Kassam river. Here two chiefs were waiting for us with a good Danakil guide. He wanted us to turn aside and travel at the foot of the hills, whereas we wished to go across the scorched plain to reach the Awash quickly and then follow it down-stream till it loses itself in the sand in the Aussa Sultanate. On the road we saw many birds with wonderful plumage, also gazelle and jackals very near. That day we camped at noon on the east bank of the Kabanna, a wide and stony river, and in the evening pushed on northwards, but were forced to spend the night on a barren plain, where there was no forage or water. So next day we sent the guide back

as we wanted to strike the Awash as soon as possible for water and animal feed. After crossing a plain, barren except for the last portion, we reached the Awash at Dobbi Faghe and found a good camping place. The river, which was muddy here, was bordered by a belt of forest in which game was very plentiful. There were guinea fowl and doves by the thousands.

The news that our two best mules had run away was very disturbing, as it would probably be impossible to obtain others anywhere on the expedition. We therefore sent back two men to look for them over the road we had come along from Wara Malka, and at 12 p.m. the following night they came back with them all the way from Wara Malka, where the beasts had returned as we had anticipated.

At 8 a.m. on April 4 we left Dobbi Faghe and crossed the Awash near the camp, the thick bush making it difficult for the camels, loaded high and looking like moving houses, to get along. We saw many boars here and antelopes as big as calves. Leaving the river, we traversed a black earth plain, progress being hard for our animals as the innumerable cracks and softness of the ground made them flounder. This was particularly trying to the camels, which got scared and growled more than usual. We met two Danakils, who ran away frightened. These people are more savage than the animals living in the forest. At 11.30 a.m. we arrived at the Awash again and camped near it at Unté, where the stream runs over rapids. A small Danakil family approached: the man, a beautiful type, young, over 6 feet, as pure lined as a handsome white; the woman ugly; and the daughter, a girl of some eight years of age, very sweet looking. At night many more came, women especially, driven forward by the men, and asking for beads, etc. That evening there was a slight fall of rain. Game, especially boars, was still very plentiful. The next day half a dozen Danakils followed us, two as guides, the others out of curiosity. They were fierce-looking, tall, slender men. We crossed the Awash, and after an interval recrossed it again by a rather steep but shallow ford.

The river banks were crowded with virgin vegetation in the shape of the trees and lianes, somewhat like what I had seen in Venezuela though much smaller. The mimosas were very large. This forest belt, which we first came on at Dobbi Faghe, accompanies the river throughout its course till it ends in the Aussa Sultanate. In places it is very thick, with a growth of smaller bushes and vines. Crocodiles were plentiful in the river and basking on the banks. I saw a scene of monkeys frightening birds, a subject for a Chinese wood engraver.

We left after rain at 5.30 p.m. and arrived at 6.30 p.m. at the village of Ontutti Omar in the region of Adalia. Our next march was over a flat area good for motoring, and later a grassy undulating plain led to the Awash again, a very pretty spot. After spending the afternoon at Sublale on the river bank we camped that night on a dusty plain near the village of Additale. Mosquitoes and the camels rubbing their backs in the dust made rest unpleasant.

Still marching north, roughly parallel to the Awash, over a wooded, grassy plain, we reached next morning the village of Kortumi, where we wanted to camp near the river, but the chief suggested a better place which, as I expected, proved to be impossible. As soon as we had unloaded, a 7-foot snake, said to be very poisonous, crossed over our bags and boxes and was subsequently killed,

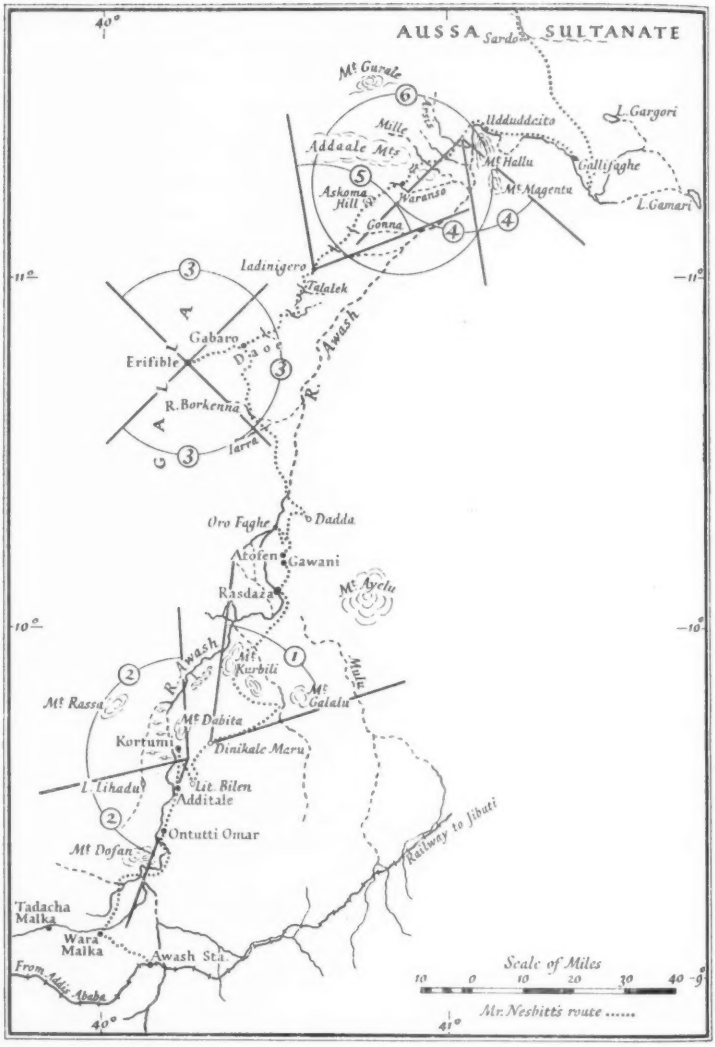


Diagram showing the points from which Mr. Nesbitt's sketches were made, with their range

after a general stampede of the visiting natives. These Danakils cannot use their spears very well. After fifty stabs they had not got their points into the snake. In the morning we saw game in plenty, large water buck, and monkeys by the treeful.

There was endless parliamenteering with the chief and with the *dania* (*i.e.* judge), a passing inspector collecting taxes, one Ato Sale, a runaway from the Greek party massacred in 1922. These people wanted us to turn back two stages, cross the river, and get to the opposite bank and travel on that side, as the tribes on this side were on the warpath against those of the other and would make our progress here dangerous.

All sorts of insistent talk went on for four hours, trying to convince us about going over to the other side and travelling at the foot of the hills, *i.e.* considerably back from the river, the road also suggested at Wara Malka by Ibrahim, the Abyssinian chief who raids the Danakils. But we ourselves did not want to go back these two stages and then follow a road which only in two weeks would bring us to Bahdu, whereas if we went our own way we would reach it in three days—or so we thought. Accordingly we decided to follow our original plans.

The next day, April 8 and Easter Sunday, we spent till evening at Kortumi. Scores of people crowded around our beds for medicines. In the afternoon we had a long talk with the *dania*. At last we loaded up and decided to leave, but he stopped us. He wanted to see our passport. We had none, however, except one for travelling in certain provinces on the plateau near Addis Ababa. This we showed him and—for he could read Amharic—he then said that the route we wanted to take was not mentioned. This man, a real nuisance, caused us a lot of bother. Finally, on our saying that we were going at our own risk and that he would not have to worry about us, he requested a note signed by the three whites to this effect. This we gave him, but when we were at last about to leave he stopped our men "on Menelick's word!" The five servants brought from Addis Ababa went over to him and refused to follow us. Some had already surrendered to us their rifles, cartridges, etc. In this unfortunate situation we could do nothing but give in and follow the *dania's* instructions, *i.e.* return on our tracks, cross the river, and follow the route below the hills, which would be an extra ten-days' trip. It being impossible to go without men, we took one of the guides ready for us in the event of our deciding to comply with the *dania's* instructions, and turned back, making camp after an hour-and-a-half's march. That night rain came and everything got wet; also the mosquitoes never stopped bothering us.

Next morning the rain persisted hard till 7 a.m. We now dismissed the three guides who had followed us for the last three days, and, being some distance from the village, instead of going the way suggested by the *dania*, we turned sharp east. The men growled a little, but we told them we were going to Afdam. After an hour we got near a long, low hill which we followed south for another hour. Eventually we stopped at a hot spring, Little Bilen. From here we hoped to cross the low hill, and once on the other side to be safe from the interference of Easter Sunday.

In the afternoon we wanted to resume our journey, but a chieftain with some companions came and greeted us with many salaams, to which we hardly answered. These people prey on the traveller as the vulture waiting for the

sheep to die. The visit of these intruders made us suspend our preparations for leaving as we did not want to show the direction we were taking for fear of the *dania* sending after us or interfering with our plans, which had already suffered enough. However we had to entertain the chief in some way. He was a good-looking, straight-nosed man of about thirty-five or so. Naturally he asked for baksheesh and in the most brazen of ways. He got something, but not as much as he wanted. As he was very insistent we told him to come back in the morning. This quietened him, so after a bath at the hot spring he left. We later went out for a walk and saw a very large dead tortoise from which we removed fifty-two unbroken pieces of shell. We judged that the tortoise must have been at least three hundred years old. I also saw beautiful oryxes, antelopes, and jackals.

That night, though ready to leave at midnight, we rigged our tent to impress the chieftain with the fact that we were going to stay at least till the next day. This proved useful, as immediately after dinner a downpour started and kept on till the next morning. We could not leave at midnight, so we sheltered in the tent till 3 a.m. We then started loading, the moon being hardly visible and the ground very wet. At 5 a.m. we left, but the road was so slippery that an hour and a half was lost in getting the camels over a mile of clayey soil. Also one camel got lost in the darkness of the dawn; but it was found after half an hour's search. At last we left in complete caravan, traversed a plain, largely swamp, and started climbing the long, low hill skirted yesterday. On top of this, at about 9 a.m., the rain stopped. To protect ourselves we had been wearing sacks round us, which had become soaked through. Now at last they could be removed.

From the top of this ridge, which we followed for a good while, the panorama was wonderful. The Kachinoa Mountain, isolated in its beauty, the Tadacha Malka behind Wara Malka, on the other side of the Kachinoa, the Sabo, a lofty eminence on the summit of which is a Copt convent, and thus all around the compass, as far as the eye could see, range upon range of hills, some isolated volcanic peaks, others smaller, like mamelons, and in between plains blending with the azure of the hills and the paleness of the more distant mountains. A landscape not to be forgotten, and now enhanced by the play of light and shade, and the shadows of great white clouds sailing in the sky, the result of the rains of the last two days.

We continued into a long narrow valley where we wanted to shoot some ottardas, a large bird, as tasty as a turkey. Finally, at 11 a.m. on April 10 we arrived at a place near a water-hole called Dinikale Maru. Again from here the landscape was beautiful; ahead was the Bahdu mountain Ayelu which we were to skirt next day. At noon it was very cool and spring-like. In the afternoon Pastori and I went reconnoitring and correcting maps. We walked a mile on the plateau we were now on, having climbed one terrace higher, which was the topmost. From the western rim of this a most beautiful vista unexpectedly appeared. Of this I made two sketches (No. 2 on folding plate). The lagoon was beautiful, emerald green, the foreground a swampy plain, now dry, on which every detail was noticeable. I wanted to take a third view, but we had to return. Then in camp I made another sketch (No. 1).

The night was cool and windy. We got up at 4 a.m. and left at 6 a.m. The old guide brought us a new one that morning right at the moment of leaving. When we were on the route both guides turned us down, asking fabulous increases in

their pay, entirely out of proportion to their services. So we let them go, forfeiting what we had already given them. During the early hours of our march we could not fix our direction as the morning mist was heavy. We had never experienced a similar screen before, and just to-day, when we wanted a clear horizon to steer for a prominent landmark ahead, a truncated cone-like hill on the Galalu plain, this and all the other eminences on the landscape were quite invisible. With confidence however we went ahead, and only after five hours' trek, the latter portion of which was very hot, did we see, and dimly at that, this famous hillock. We were still quite right on our course, though in many instances we had had to leave it to skirt thorny bushes and impassable thickets, which covered acres and acres of the plain. Game was more abundant than ever before. We saw herds and herds of antelope, gazelle, and buck, also ostriches and the spoor of zebras. Birds were also numerous.

From 11 to 1 the heat became almost unbearable. Only one riding mule, mine, was available, as the others were being used by two of the servants, who were sick. So with my mule I went ahead looking for water, keeping a course parallel to that of the caravan, but found all the hollows dry. At last, at 1 p.m., after marching seven hours, we came on a muddy pool holding in all not more than 20 gallons distributed in dozens of hollows left by the hoofs of cattle.

The water was filthy and so thick and muddy and slimy as to be fit for nothing, not even for watering a street in ordinary circumstances, yet we drank it with joy. We knew there must be water near here as three Danakils came up to us and we heard cattle lowing. A village seemed to be moving to the grass. Whole villages wander here, for these Danakils are a nomadic race. They do no work, live on milk and meat, and raid their neighbours, existing thus in the direst poverty, ready to attack or run away.

Near here are the two hills at the foot of which were massacred recently the two Greeks and their fourteen men who were collecting live zebras for zoological gardens. One Greek succeeded in escaping, being sick in his tent when the massacre took place. He eventually arrived at Awash to tell the tale, which I had heard from the Greek ex-Seminarist who had accompanied me shooting one day.

The sky north of us that afternoon was a mass of dust. At night the natives of the village on the move, who had camped near us, approached with a number of women, some of whom were very pretty. They brought milk as presents, the presents of this country, and got flour and beads in exchange. They seemed a better type than those we had met so far, being clean and nicely featured.

Every night different sorts of insects were attracted by the candle-light. The night before it had been blue-winged termites. This night it was small, hard little black beetles. Scorpions and ticks were plentiful. It was very dry here and not so hot, but the sun reflecting on the dry grass and sandy patches was rather hard on the eyes and the continuous blinking was tiring.

Next morning, April 12, we left at 7 a.m. and travelled over a very rocky region, strewn in places with basalt and lava, and twice crossed the Kubedadda torrent, dry and muddy, with only a few water-holes here and there. The local chief's son had accompanied us to make up in some measure for the fact that his father was absent when we called on him. This lad was apparently interested in something about me, because he walked at my side and kept looking and

looking at me from head to foot, mule included, for minutes at a stretch without moving his stare except to recover his balance when the stones with which the ground was strewn almost made him fall at every few steps.

As soon as we left the bank of the torrent we entered a dry plain. On this boundless expanse we skirted the foot of the long, low hill we had rounded in the morning, thus avoiding the deep valleys, deep basalt gorges in the same hill whose summits we had taken for our direction early in the morning. This hill seemed to be quite short, but we soon found that it was much longer than we had imagined. On the desert plain we crossed we saw beautiful antelopes and zebras at quite close range. To our surprise the hill was interminable; at night time, after four hours' trek, we seemed to be still in a position similar to that at 3.30. p.m. As we were looking for a likely place to rig our tent near a water-hole which we had found, suddenly the chief's son jumped in and bathed in it, regardless of the use we had to make of the water. The Danakils will jump or wade into the water like cattle when they want a drink. We camped near a group of cattle, our guide having told us that the chief was about there. At last this important man was found, and he came to our camp, having returned on his steps to meet us. He kissed my hand twice, asked for cognac, and then went to eat with our interpreter. His son meanwhile had gone to look after the camels and cattle his father had abandoned to come to us. The guide was to be changed, so the chief left us to find one. It is remarkable how news travels in this desert. The natives call it the *dago*, and when they meet, stop to rub hands slowly together before delivering the news of the day.

The few people one meets are rather shy at first and try to pass alongside as if they saw nothing, but after some familiarity they become as inquisitive and troublesome as monkeys.

The new guide arrived in the morning, an elderly man with a face as dry as a mummy, and we left at 6 a.m. after half an hour's delay through light rain. We continued on the barren plain of yesterday afternoon and gradually came near marshy stretches, and later real marshes full of reeds and stinking water. We now approached the foot of the long hill. The plain here was clayey and as level as a billiard table: the hill, of barren basalt, was eminently volcanic, and the contact as sharp as if cut by a trowel. To keep out of the marshes we had to walk on the rocks a few feet above the edge of the water, which was as brackish and as black as that after rains in the ditches outside a cattle stable. Birds were rare, a few airons and others, but there were signs of hippopotamus everywhere. We continued on this endless trek beside the hill, rounded a few spurs, and eventually suddenly came in sight of the Awash. Here we had to abandon one of Rosina's mules, which showed serious signs of collapse.

We now kept near the river, at one of the bends of which I saw about a dozen large crocodiles, four of which were basking within a few feet of me as I stood on the bank some 10 feet above them. I made signs to one of the boys for a rifle, but by the time I came back several of our caravan had come up and all the crocodiles were naturally by now in the water. I nevertheless had a shot at one peering above the water, and got it.

The plain had now ceased to be swampy, and had given place to an unlimited grassy flat. Our mules, which had eaten nothing the night before, could not be controlled at such a wealth of forage. Rosina, rather sad about the lost mule, put

the blame on the hot mineral waters which from hundreds of holes oozed from the foot of the hill we had just skirted. On this beautiful grass signs of cattle and stock raising were now evident and became more so as we went forward. The other side of the river, near which we were all this time, presented a similar landscape except that the boundary was not visible and the plain on that side of this level Awash valley seemed to stretch *ad infinitum*. The huts of the savages became more numerous, divided into groups by hedges of dry thorny branches. Whole families came out to watch us, the men with a fierce look, as if each were ready to gain fame by killing a Galla or any stranger, and thus be able to wear a bracelet or a feather on his head until one year from the event had elapsed, and then to cut a hole in the lobe of his ear.

The groups of huts in the tall grass became more considerable in size, and at one point there were a few dozen of them, half on each side of the river, and numbers of cattle and sheep, as well as a few horses which are only used for raids, but are of a good strong breed. The crocodiles by the hundred did not seem to bother the animals drinking at the water's edge, nor the women in groups filling their gourds. I watched an interesting incident of cattle swimming across a ford between yelling herders, who were chasing away the crocodiles above and below the swimming cattle.

We continued, after seeing more and more crocodiles, egrets, and marabouts, till we stopped after five and a half hours' march at the river bank under an enormous tree facing the Ayelu Mountain, to which the interminable long low hill adjoins. Mount Ayelu is a spent volcano, and I should think the long hill was due to an upwelling of molten matter all along a crack which caused this even ridge of some 35 miles in length.

We had now come through Magu and were camping at Rasdaza on the east bank of the Awash.

In the afternoon Pastori and I shot two hippopotami to please the local chief and his ten followers who came to greet us. They cannot shoot hippopotami as their guns are old and their ammunition bad. They were very glad of the bag we got for them, and sent us a sheep as a present in exchange. The chief came with a party next morning to see us off. We had looked for the two hippopotami shot yesterday evening, but we learnt afterwards from the chief that during the night his men had taken them ashore, and shared and eaten them.

We now crossed a dreary sandy plain covered with thorny bushes, a very hot trip. Mount Ayelu was most imposing in the background. We crossed a small stream, then sandy ridges, and finally arrived at the water-hole of Faha. Here sheep and horses grazed under the long horizontal bedding of sandstone cliffs, beside a spring of salt water under a few scattered mimosas.

More desert and sandstone ridges, past a water-hole of disgusting taste, and then we reached the centre of the Gawani plain, a thorny and dreary stretch, with three men of our caravan sick. We stopped at Gawani village, five or six huts only, though well marked on maps. Here there was the endless procession of women, girls, children, men, begging for beads, flour, sugar, cartridges, etc. Next morning the chief came back with a chair, the much valued prize of some raid. He had marvelled at our lack of chairs. They are the only article of Western comfort known here, and are regarded as thrones for

nomadic rulers. He had coffee and arranged so that we were forced through his misplaced benevolence to stay and keep him company for the day. This was the hottest day of the trip so far, in that dreary, scorched, sandy waste; the sun was blazing in a terrible manner. The water too was very bad; a hateful stay just to please that burly chief, whose mirth and geniality enlivened us, it must be owned, through many hot hours. He was a small, thick-set man of some fifty years of age, with five wives. He said he had slain by his hand and with his dagger six men, Gallas and Issas, and showed us the weapon as usual sharpened on both ends and still showing the marks of the dried blood near the hilt, the signs of his last fight, not to be cleaned. He told us that when Momi, his brother, was alive three years ago, slaves often passed through here for Tajura. Also lately twenty men and thirty women came through for the same destination. These slaves are sold (the men) at 1000 Thalaris Maria Theresa (about £100) each to the Arabs on the opposite coast of the Red Sea.

That evening we moved on to the neighbouring village of Atofen, where the whole village turned out to greet us. The chief Abdulla, nephew of the old man we had just left, was a middle-aged man, of a degenerate look, in a khaki costume of a sort. A *dania* also happened to be visiting the place and, though ignorant of Amharic, pretended to read our passes, which were merely letters in Amharic, and declared that they were all right. With groups of spear-armed men and women and children all around us, we made our preparations for the night. They were so annoying they had to be chased away like cheeky animals. The chief and *dania* wanted us to wait for the answer of their bigger chief as to the route we should take. This worried and annoyed us. The waste of time caused by these stupid talkings was hours and hours a day. They claimed that there was danger everywhere, that the Danakils might prey on us overnight, if not by day, thinking that our luggage was full of valuables. There was no food for the camels or mules here, and no water to speak of, except a muddy clayey liquid unfit except in such extremes as we found ourselves in now.

Next morning we were up long before the lazy population of the village 100 yards from us. The *dania* came, not a bad man, and said he advised letting us through, but the savage ignorant chief was afraid. He refused, strange to say, presents in money and coffee, and only asked for a hundred revolver cartridges to be sent to him. Noon was very hot. This desert was unbearable, hot and dusty, but luckily not as much as it could be, thanks to the rains of the past days which had cracked the clayey surface. Now this was marked by millions of cracked and curled-up flakes.

At night the chief's brother, a criminal-looking man who caused trouble from the start, raising all sorts of objections, came again, and got some cartridges from us. He left us saying that in the early morning he would be gone on a tour to the neighbouring villages to arrange about a raid to take place against some enemy tribe in a few days to come. His brother, the chief Abdulla, controlled a large tract all the way from the Kubedadda torrent to where we would be the next day near Mount Sibabi, close to the Awash—that is, all the desert plain west of Mount Ayelu.

Next day, April 17, we continued over this desert plain, and later a swampy portion, at the time dry and covered with dead reeds, till we reached Oro Faghe, in a belt of trees bordering a branch of the Awash. This appeared violet

and green in the distance owing to the colour of the unawakened branches and of those which had just started budding. We were accompanied for the first third of the journey by the chief Abdulla, who said he wanted to see us safely out of his territory and wanted a paper from us stating that we had reached his boundary all right. But the heat stopped him near a village perched on the slopes of the hills near Mount Sibabi. Mount Ayelu throws out a tongue or ridge in the Sibabi direction, and this latter group of two or three small summits terminates it. Good specimens of chalcedony and jasper were found. One of my personal servants was sick with fever, so we handed him over to the Abyssinian *dania* who was soon returning to Afdam, where my man could return by rail to Addis Ababa.

The place where we camped for the day was very shady. The river water, though turbid, was most welcome after the dirty, disgusting water of the Ayelu plain. Crocodiles were abundant in this branch of Awash and one had to be careful not to be dragged in by one. In the evening, at about sunset, I was bathing in the river when several shots were heard. At first I thought it might be Pastori or Rosina shooting game. The reports seemed to come from quite a little distance. Then more shots rang out, these nearer still, and somehow or other a sense of danger entered my heart. My boy, to whom I had given my line to continue fishing as I was washing on the river edge, said that Ate Bayona, Wolde Georgis, and Maconnen were out cutting grass. We were hastily getting up when we came upon Rosina's boy, who said that the Danakils were shooting our men. I ran to camp only some 100 yards away and heard Maconnen calmly deliver the news that Bayona had been killed by a shot below the heart. Several of our boys rushed out and we had to drive back a few to leave one or two rifles in camp. Meanwhile Wolde Georgis arrived and he gave more details. He was cutting grass with Bayona when the Danakil guide, who had been recommended to us by the old burly chief of Gawani as an extra guide, came up. He approached Bayona, apparently with friendly intentions, though they could not understand their respective languages, and then suddenly, at a few yards' distance, shot the unfortunate fellow. Bayona had left his rifle near his coat some little distance away, but in any case would not have been able to use it as he was taken by surprise. Wolde Georgis said the Danakil next had two shots at him to which he answered. In all there had been eight shots in the space of a few minutes. A little later Pastori and more of our men came back, carrying Bayona's coat, hat, and rifle.

The guide we had with us had lent his rifle to the criminal, a well-known unruly man of a near-by tribe, who had been sent to the chief of Gawani by his own chief to carry certain news. As he had to return and our way was his, the old chief of Gawani sent him along with us. It appears that this young man wanted to get married and had to present his fiancée with the testimonial of his prowess.

The guide who returned to camp with Pastori wanted us now to leave immediately and return to Atofen to the chief Abdulla, as he said the friends of the slayer would attack us during the night. But we did not want to shift in the dark, and though the place where we were camped on the bank was very open to attack we stopped for the night, having fortified ourselves by piling the bags, and baggage sacks, boxes, etc., into a square around us, within which we tried

to sleep till dawn came. Fortunately nothing happened, so at the first light we got up, and Pastori and I and three men went out to bury the dead fellow. We found nothing of him however except a few rags, as the body had been devoured by hyenas. I made a sketch of the place of the murder, which happened in the thick, reedy grass patch between the low sandy hills. Pastori took one of the men and went to a near-by group of two or three huts to send a man to inform Abdulla of what had happened and ask him to come to meet us. When I got back to camp we decided after a time to move away from the spot, so we travelled back across the dry straw-strewn plain until the heat became unbearable and we stopped for a while under some trees. Soon after we resumed the journey we were joined by Pastori and the man he had taken with him. Presently several Danakils met us, having come to escort us, fearing further trouble. At noon, after a very trying stretch, we at last arrived at a water-hole where we stopped for the day to wait for Abdulla. We had thus gone back on our course.

For two hours we talked with a local chief trying to secure guides for next day. Abdulla did not arrive till dawn, when all the parliamenteering started again and lasted three hours. The result was that we were to leave in the afternoon for another road. These changes were very depressing and intensely irritating. The prattle, prattle, prattle would go on in the most monotonous tone for hours and hours at a stretch, and all this through the medium of a translator, the Danakils squatting in a ring and spitting or leaning on their lances. Then they had coffee, then they asked for sugar, then for this, then for that. They were never satisfied, and were more curious than monkeys, more bothering than horse-flies in the summer. Hardly any of these people had ever seen a white man before, though they were old. They said that seventeen years ago one had passed that way.

The local chief was the most poisonous type of a man for worrying one: never satisfied, always asking and taking things which had to be taken away from him again. First he wanted a spoon, then a fork, then a plate, then a cartridge, then some money, and so on with everything one touched or he saw. At the last moment he took away a mug and tried it again a few minutes later, then he dived into the pockets of the men, without sense of shame, just as a monkey would do. And all the time one has to be very tactful with these people, avoiding irritating or contradicting them roughly. They will murder even each other at the slightest provocation and often just for sport. A stranger is a prize and a white a higher one. The recent Greek massacre referred to above brought on them however a timely raid, the Gabili tribe, which was responsible, being annihilated and Abdulla's suffering also as a neighbour, though not directly implicated in the affair. The Abyssinians took away from them 13,000 head of cattle of all sorts, a fantastic number judging by the extreme misery of those races. Abdulla therefore was now accompanying us to safeguard himself. At last, at 4 p.m., we left, the camp having all day been crowded with people and animals. The men stink of mutton grease with which they stuff their long fuzzy hair, and this melting with the heat of the day fills the air with a strong smell. We left and partly retraced our steps, keeping closer to the hills and eventually crossing some of them on a path farther east than the previous one, and which took us near miserable groups of huts, five or six

together at the most, stuck under the cliffs in a desert region. We had seen no cultivation of any kind since Awash (except the remains of the European garden at Wara Malka). These people live on milk and meat. The poverty and squalor of the huts made me think of the shelter of wild animals. They were as primitive as could be in construction, a few sticks bent in the shape of a small cupola and on these a few square mats made of reeds, the dwelling so small that two people lying inside would fill it, and the height not more than 4 feet.

We now traversed a stony section. The whitish clayey hills, conical through the weathering of rains, stood out against a background of basalt rocks, and glistened in the setting sun. Not a twig or a blade of grass was in sight, and the scene made one think of the sufferings of thirsty animals. At 7 p.m. we arrived in a gorge so narrow and dangerous that I insisted that we should turn back a little to where the valley was wider. The place is called Dadda. So we went back a little and camped in a wider space near a water-hole, very muddy, but with some water in it nevertheless. The continuation of the Sibabi mountain is a series of volcanic hills called Assassibabiforo. A strong wind that night and later rain made sleeping impossible. The other guide arrived next morning with his wife and a bull and two calves; he took all his belongings along with him, woman included. We traversed a portion again of the desert plain bordering the hills, then the dry swamp which follows and borders the river. At the ford over the Awash, whose name we could not learn from the few Danakils watering their cattle, the water was fairly high, the camels going down to the hips, and the mules swimming. I swam the river too, thereby exciting the curiosity of all, for the Danakils are not accustomed to it, and wade when they can. When they cannot they stay on the other side till the dry season comes. The place, we learnt later, is known as Barakala.

Abdulla the chief had come with us, and he forded the river too, though his territory ends before this. After many salutations we left him and traversed a dreary plain, then rising ground, clayey and thorny, till we came in sight of a village standing alone on a small flat sandstone hill, entirely isolated on the wide level desert plain. It looked like a fortified place, a very strange sight. We learnt later that it was the village of Bayona's slayer.

The hills started again and we were on clayey soil when suddenly a tremendous wind began to blow with the greatest violence after a few spare drops of rain had fallen on us unexpectedly. The heat up to now had been fierce. The first drops were welcomed, but they were almost immediately followed by a shower so heavy and so driven by the wind that each drop felt like a pinprick even through our clothes. The dust, in spite of this heavy fall of rain, was so dense as almost to cause darkness. My hands, though they had not touched the ground, were full of grit and sand. A few minutes of this rain were sufficient to drench us, but it was welcome. The ground unfortunately became very heavy and slippery for the camels, but as soon as the downpour ceased we resumed our journey. Still in the distance, for we were now on higher ground, the immense plain stretching in all directions could be seen swept by these low clouds bursting with all their fury on the parched soil.

We camped in the dark with no forage for our mules, which had been suffering hunger for the last eight days. We had now gone about half of the way

between the ford where we had said good-bye to Abdulla and the Iarra stream, another five or six hours' trek ahead of us. Abdulla's warnings about keeping all together, so as to make a close line of our caravan, especially in traversing the plain near the hill Dulale, were adhered to. The plain is inhabited by a very dangerous tribe, and the fear felt by our men was visible in their faces.

Next day we continued on that dreary, dry, stony ground, literally covered with cobbles and surrounded by low hills. Then a plain stretched around us, clayey and desolate, with no signs of life of any kind, but the views from this higher terrace were immense though of a monotonous nature, stretching beyond a broad plain to a far chain of hills. On the terrace we were gradually descending one or two dry stream beds were crossed, and later at a most desolate spot were seen more of those death memorials erected to the Danakil braves. These consist of a lot of dry trunks of trees brought with much difficulty and piled together, and in front a row of flat stones set on edge, each stone denoting a life taken by the hero buried under the pile. Near these is a small circle some 6 feet in diameter surrounded by thorny twigs in which cattle are sometimes sacrificed. One of these piles was erected to the memory of a Danakil who had slain fourteen men, but he in the end was killed by an Issa.

Later we came to a belt of mimosa and acacia trees, pointing to the fact that some water should be near by, and the Iarra bed came in sight soon after, but it was dry. A little later we found a good water-hole in it and I changed my supply of Awash water for this. Crossing the dry Iarra bed we travelled over the same plain but now enlivened by trees and bushes. We saw dik-dik several times, also birds in plenty, especially francolin, and guinea fowl, and jackals near an abandoned village. A few tombs were also seen on the horizon. The night was cloudy, but strangely enough gave sufficient light for us to reach in good time the bank of the Borkenna river at a place called Dalle Faghe, at the foot of the Korbati chain, a little to the east of the Ardgera summit. The night was very windy and there was some rain. One camel was abandoned here exhausted.

The next morning, April 22, we made an early start and soon saw that had we gone 200 yards farther on the night before we would have found a far better camping place amidst trees to shelter us from the strong wind. We here crossed the Borkenna river and next the plain, a tree-covered belt, leaving the river to the left. This belt showed as usual game in plenty and birds of all kinds owing to the water-holes here and there dotting the river-bed which, being stony, affords very clean water. The only trouble is that these Afars or Danakils, when they see water, wade into it first to have a drink. They act like cattle and cannot be made to understand the importance of leaving the water clean for others. If there are half a dozen water-holes near one another they are sure to try and pollute them all unless one shouts at them. The primitiveness of these tribes is beyond imagination.

We continued our trek in the tree belt for half an hour, soon beginning to climb along a sort of a path which was so rocky as to hinder the camels' progress greatly. One of these poor animals had to be abandoned on this steep path. For the last two days, though he had gone unloaded, he could hardly follow the rest, and always with growls and grunts to move our pity. The marches we had

gone through were stiff enough, and the lack of food and water added to the hardships of these faithful beasts. Our mules also seemed to keep alive only by a miracle; the night before they ate wood, the branches of a dry tree to which they were tied and all the dry wood of the bushes near them, not to mention the fallen bark scattered about from the dead trees.

As we climbed, the gorge of the Borkenna was on our left. This turned west while we continued up and up until we crossed the summit of the mountain next to Mount Ardgera, but our surprise was great when instead of any sign of a plain on the other side there were mountains all around. The climb took us some two hours. We descended next for another two hours or so, both ways being very rocky and full of boulders. The rains even in the desert plain below had cooled the air. Now at some 3000 feet altitude it was much more refreshing. The descent took us to a dry torrent-bed, where there were large mimosas on the banks and small patches of flat ground near the stream. Here good water-holes were found, and soon after we came on a group of Danakils and several women under some large horizontal umbrella mimosas. Three men were busy making fire with sticks, passing the vertical piece to one another after a few rapid turns had been imparted to it by rubbing the hands holding it. One man kept the horizontal piece firm on the ground with his foot. After about ten minutes the little cotton in the hole started to smoulder and was then inserted in a piece of dung like the kernel in a nut.

We now met several groups of people tending goats, sheep, and female camels. They were not all armed with rifles; some had sticks only, a sign that we were in more peaceful surroundings. We continued on the torrent-bed for another hour and stopped for the day at a place on the bank under some good trees. We were in a gorge, the basalts, ochres, and signs of manganese making me think of similar rocks in Sardinia.

The road next morning, partly uphill, partly down, and often on the torrent-bed, brought us on to a plateau which resembled the Abyssinian lofty plains. We welcomed the sight, as it meant being out of the desert. In fact, some spare grass showed, and the air was cool. Our mules were now able to eat grass after ten days of woody forage; the last time they had had some grass and in plenty was on April 12. Since then they had often gone for whole days without any food except a few handfuls of durra flour.

Here also was a better type of village, the huts, made of the usual bent sticks with matting on top, being better built and more spacious. We descended gradually to the rolling ground of a broad valley and stopped near the foot of a hill which is crowned by a small village. This region is called Daoe, though the market-place and larger village of that name is four hours from here. The local chief came to see us and sent two loads of water from the well Eba Ledara in the vicinity. The miserable village near by sent all its members to see us; all day long we had a crowd gaping at us. Later the chief came again: he said that his territory was safe and told us that had we continued along the Awash after leaving Abdulla's tribe we would have been among safe people. Our detour to reach the plateau and thence Aussa had certainly meant an annoying delay.

This was the last Danakil village, for we had reached the borders of the Galla country. It was now almost a continual climb up to the plateau and the landscape changed more and more, becoming the typical Abyssinian scenery

of the highlands. We must have been at 1500 metres here as the *Euphorbia candelabra* were plentiful now. Also signs of cultivation became more and more accentuated, and it was interesting to see the valleys below tilled in square patches here and there just as I had seen elsewhere on the Abyssinian terraces. Many ox teams were at work. They must have started ploughing and seeding durra just after the recent rains. The villages, too, were more numerous. The people were Gallas. The squalor and misery of the thieving, unruly Danakils of the plain had given way on the highlands to a better, more industrious race. Nevertheless the Gallas are warlike also and often plunder or raid the Danakils of the Awash, and being more numerous they generally beat them. We experienced some fear when two Danakils of our party were late in catching us up after drifting to a side path to get some water. These Gallas would soon mutilate a Danakil, if not kill him outright.

We camped at noon in a torrent-bed, the little stream running just under our table which we had had to set up here to be in the only shade available. The next morning, April 25, we arrived at Erifible, a market-place near Mofa surrounded by villages of good-shaped tukuls among the neighbouring hills. We stopped here four days, engaging four new men to replace some of our party who were unsatisfactory, and buying fresh camels. On the fourth day the market was held, and we saw the salt-laden camels coming in carrying bags of woven palm leaf, cylinders about 30 inches by 4 inches, full of rock salt as hard as stones.

On April 29 we set out again, and having retraced our steps to nearly the place where we spent the night of the 23rd, we reached the village of Gabaro. Here insects were very troublesome and wriggle-worms seemed to be plentiful, while the horse-flies drove our poor mules simply crazy. We had planned to leave again in the late afternoon, but a storm came with violent rain and compelled us to stay here. It rained almost all night long. Next morning, having gone north-east through stony ground, we crossed the dry bed of the Ereidera. In the afternoon again, as yesterday, there was a downpour which lasted an hour and a half. The prettiest multicoloured birds, of different varieties, the size of a blackbird, were so bold as to come within a few inches of us. That night it rained almost all the time.

The first half of our next march, on May 1, was muddy and grassy; the last very rocky going. We ascended a good deal and came to a stop at Barrita, near a river of that name. Here again it rained all night long and the torrent a few feet in front of our tent was so swollen that we had to wait till about 10 a.m. next day before leaving. After fording the river and following it downstream for a time we left its course and took a steep uphill direction, and soon at the summit struck a dry torrent-bed which we followed all the way down to its confluence with the Talalek, which we found swollen with the recent rains. The torrent we followed was often a narrow gorge within high vertical basalt sides: a very prohibitive landscape with no signs of life anywhere, not even a bird. As the torrent bed descended we were only too glad to get out of that rocky bed, as it spread out fan-shaped and reached the Talalek, a good-sized stream. Here we filled our ghirbas with the muddy water because our next stop was to be dry.

After this river, where I noticed beautifully exposed roots of trees and

canyon-like cliffs, we ascended a small group of hills, and great was our joy when, on beginning our descent, we saw the enormous Awash plain stretching as far as the eye could reach in front and on two sides of us. It meant that our next march was to be on flat ground, no longer one of mountain climbs and descents. Even Mount Ayelu was visible: that terrible mountain which saw so many of our trials for three weeks was still to watch us. We felt that we wanted to get away from the horizon which held it still.

The descent, interrupted by one or two more small rises, brought us down into the desert plain. We had circled for some ten days on the rocky mountains to get on to this side of the Awash, and we could now see the unfriendly river in the distance where a dark patch of trees indicated its presence. A few caravans were now met, going and coming from Aussa, all carrying salt, but of a miserable aspect, with a few straggling women and unarmed men. The desert was of the same clayey character, but now blistered by the recent rains. Signs of deep erosion were noticeable everywhere, and these often caused us to detour. We arrived in the afternoon at one of these gulches only a few yards deep (the general name of the locality is Ladinigero) and stayed for the day and night, as our camels were very tired with the mountain marches of the past days. (See sketch No. 5.)

Next day, making for Askoma hill, a prominent landmark, after a trek over desert ground full of signs of erosion, we came on a dry torrent, the Bussidima. The following day, still crossing the desert area, now more than ever broken by erosion, and always bearing towards Askoma hill, we reached the Gonna torrent-bed. Here a few water-holes gave us far better water than we had had for the last two or three days. That night there was a full moon and a beautiful cirrus sky, but it was somewhat damp. Jackals came running through our camp several times and were easily visible in the strong white light.

Next morning, May 5, we left at 6.30 a.m., and after two hours reached the Askoma hill, quite an isolated eminence some 75 m. high, which we skirted on its east side after crossing a torrent called Ledi which ran close to its foot and contained good water due to the recent rains. The rocks were volcanic, a strange honey-comb lava, many coloured and very beautiful. The road continued over dry sandy and gravelly ground, and we finally reached on the left of our path a torrent with good water. This is called Waranso, near the Addodas well. We stayed there for the day and night. The weather was now dry, but the progress was slow, only four hours a day. Camels here are not the wonderful beasts they are described to be in the north. They soon get tired, and once run down they either die or take a year to recover.

Next day, after three and a half hours' march, we camped beside the torrent Baddanna. We went mostly eastward over desert ground as on previous days, crossing the torrent we had camped beside the night before, about three miles from the foot of the Addaale chain, and skirting these mountains. Soon after crossing the Waranso I took the four horizon sketches reproduced with this paper (No. 6). After a very hot afternoon in camp we left the Baddanna camp at 7 p.m. The wind was a gale till 8.30 p.m.; later it abated, and the moon at last rose out of the clouds. We travelled till 10.30 p.m., all very tired, and camped on the sands beside the Mille, a very nice and clean spot. The Mille water was however very muddy and made drinking a trial; the current was swift and heavy.

Next day we passed through the same kind of desert country as during the last few days. The heat was excessive. As yesterday, we met a couple of good-sized caravans carrying salt, incense, etc. One was of three hundred camels. When we camped for the afternoon beside the torrent Sidiakoma another caravan was resting on the opposite side, and some fifty men clamoured round us. Many of them had never seen whites before. The *dago* (news) had travelled through and all were expecting us as we went along.

The water here was better, that from the hole in the dry torrent-bed being somewhat muddy but not as heavy as the Mille water of the night before. In the afternoon there was a heavy fall of rain, which gave us good water, though we feared for our tent rigged on the torrent-bed. At dusk, after the rain, I went out shooting dik-dik. Many jackals came down to the watercourse and crossed it. It rained all night also, but happily the torrent did not sweep us out as we feared all the time that it might, for the streams rise suddenly in this region.

Next day we had to stop all day beside the Arsis as one of our camels had broken down and we had to send back to fetch its load. In the afternoon a sudden outbreak swelled the torrent and we thought for a few minutes that we would be washed out, though we were at some distance from the bed. However, only the flat ground became covered with a maze of streams. After the rain Pastori and I climbed a basalt hill, quite outstanding from the flat ground, and I took the two sketches reproduced here (No. 4). The Awash runs close under the cliffs. On the hill we noticed many marmots, also hiding places for snipers waylaying the caravans going along at its foot.

To rest our animals we stayed on here, intending to leave in the afternoon, but our three mules got lost and were not brought back till evening, when it was too late to leave. The two boys who found the mules said that a Danakil had roped them together and was driving them away. At this point we sent a man ahead to Aussa to warn the Sultan of our approach.

Our next march was again over flat desert ground, but now between basalt and trachyte hills, some consisting entirely of boulders of enormous size. We finally reached the Awash at Tandoho, where we camped and found very good fishing. Next day, May 11, we moved on through similar country in great heat, worse than on the previous day, but at Uddudaito, on the bank of the Awash, found a very shady and comfortable camping spot. The last bit of the day's trek was unbearable owing to the heat and desert surroundings. Close to us a caravan of some four hundred camels was unloading; they were carrying *boujadit* (cotton cloth) from Assab and had taken twenty-six days to come as far as this. They were bound for Dessie and Batie. We had now rounded the big curve which the river makes here. During the morning, when leaving the last hillocks on our right and left, at a pass (strangely enough now between sandstone banks after the ever-present volcanic rocks), we sighted dimly in the distant haze a mountain towards the left of which we intended to make next.

Wolde Jesus went out fishing for us and caught four large fish, one of which we ate fried. It was delicious, and we spent a happy evening having plenty of good food. Early next morning the moon between the tamarisks produced fantastic effects out of our preparations to decamp. The beginning of the trip was through the same desert country as for the last few days, but the

rest through the most isolated flat dead sandy plain one could imagine. It seemed an infinite horizontal stretch, but happily was not hot through the early hours. We had to abandon a camel here. At a spot where the first glimpses of sparse bushes came again we caught a pretty jackal which we kept for a time in camp. An hour later we struck the Awash again and coasted it for half an hour trying to find a possible camping spot on its brink, away from the thorny mimosas. The ground is literally covered with dry thorns and fallen branches, and it is hard to find a passage even on foot. We managed after much searching to strike a small half-clear space, which we cleared out, and here we rigged our tent. The river was close by, but not so impressive as when we had seen it that morning before daybreak, in the moonlight. At a sharp curve on the side where we camped there was a vertical cliff of some 100 ft. drop, the opposite side having the benefit of the earth carried from the eroded side and showing a clean beach which the trees had not yet invaded. This was the prettiest spot I had so far seen on this long river. It marked the curve that the Awash makes south-east here, after a more or less constant northerly course for over 100 miles. There were hippopotami and crocodiles here in the river.

The heat during the afternoon was almost unbearable, but next day, though we left at 5 a.m., we had the hottest run so far through most desolate and dry country, and all the men became exhausted with thirst. At last we came in sight of the Awash, but it took two and a half hours to reach the far-away fringe of trees which bordered it, dimly showing on the horizon. We had to leave behind one camel which could not travel further, and two men, as we did yesterday. These poor fellows returned late at night, half dead with thirst, having spent some twenty hours in the desert, for much of the time in the sands blown up by the wind to a killing dust. They left the camel behind to save themselves. Fortunately we had sent the guide to look for them with some food.

At the ford, where it was a relief to drink some of the very muddy water of the Awash, Kako, who had been sent on ahead, arrived back from Aussa and showed us where we were to camp. The Sultan, he said, was afraid of whites exploring or mapping his country, lest they should take it from him, and had wanted us to stay two hours' march back from here, in the desert, where he would have sent us camels and loads of water. Kako however told him that we already knew everything about this district, and he suggested a spot near Gallifaghe, 500 yards from the ford and 75 from another point on the river, where we could get water and wood. So we retraced our steps to this place, fixed our tents, and settled for a prolonged stay, as we needed durra and camels. In the afternoon we had a few visitors, and later in the evening two envoys from the Sultan came with ten followers. They brought two big bulls as a present from the Sultan, but, like their master, showed evident distrust of whites.

(*To be continued.*)

A JOURNEY FROM BARROW CREEK TO VICTORIA RIVER

DR. CHARLES CHEWINGS

EARLY in January 1909 the writer made an agreement with the South Australian Government to open up a line of waters, for a stock route, from near Central Mount Stuart to the Victoria river, so that stock bred in the Victoria river district might be taken direct to Alice Springs instead of by the roundabout route to Newcastle Waters, and then down the Overland Telegraph Line. Mr. F. B. Wallis kindly lent twenty camels and gave financial assistance as well, while the South Australian Government agreed to pay for any trial wells made at reasonable distances apart that would yield a fair supply of good water.

On 8 February 1909 I left Adelaide with stores for six months, including a fair supply of dried beef, which proved a great success, though because it was heavily spiced the black boys objected to it and would only eat it minced fine as a hash, with dried vegetables. We bought fresh meat wherever possible, and also took in salted beef at the last station, Barrow Creek. My three companions, John Gettens, Harry Baxter, and Richard Douglas, joined me at Oodnadatta. They were all experienced bushmen, and used to mining and well-sinking. At Barrow Creek I secured two black boys, Tim and Paddy. Paddy knew the country to the west and north-west of Barrow Creek. The Hanson Creek country he knew well, and he had been as far west as the Lander Creek. For years past the rumour had been current—derived of course from the natives—that there were natural springs in the sandhills north-west of Barrow Creek. Paddy had visited some of these springs, and agreed to pilot me to them. They were far off, however, and the trouble was to find water low down along the course of the Hanson Creek, say 35 or 40 miles north-west of Barrow Creek, that would enable us to reach the first spring. From here, Paddy said, the distances between the springs were not very great.

With the help of these springs, if they existed, I hoped to be able to reach Winnecke Creek—so named by Alan Davidson on the journey when he discovered the Tanami goldfield. The creek was discovered by Nat Buchanan, a hardy old bushman, on his remarkable journey through quite unexplored country from Powell Creek to the Victoria river. Buchanan travelled with horses, and had only a black boy for companion. His route was north of mine, and must have been through the country where the ill-fated aviators, Anderson and Hitchcock, recently lost their lives. Buchanan, it is reported, had a very arduous trip, and only succeeded in getting through to Winnecke Creek by finding a native well or two. As no one has since visited the wells it is not known whether they are permanent or only contain water for a few months or weeks after the rainy season. Many of the natives' wells in the country he passed through are not permanent.

From Winnecke Creek I hoped to reach the great south-east bend of the Victoria river, near which is the Mucka outstation of the Wave Hill cattle station. The Catfish set of yards, which are quite close to the bend, and the water-hole bearing the same name, were my real objective.

The South Australian Government had supplied me with a light portable

boring plant, and I had this so made and packed that we could cry a halt, boil the billy, and start boring for water in half an hour. We were able to carry 200 gallons of water in our casks, and when in dry country kept to the following programme: When leaving any water we had made or found, we filled every keg to the brim, kept the camels out from water until midday, when they would take a good drink, and then travelled until dark, when we tied the camels up all night and shepherded them until they ate their fill in the morning, and then travelled all day. If towards evening we were fortunate enough to find a spot that looked promising for water, we would camp, and while the boys watched the camels graze we drilled a hole as quickly as possible. If we failed to find a likely spot we tried again next day, and if unsuccessful, again the next, and so on until forced to return for water. If we found a site, and in due course water in the bore, it became a question whether we and the camels could hold out long enough to enable us to sink a well to the water. We might have saved many miles of travel and much time by taking with us a small pump and piping to lift water from the boreholes while sinking the wells.

We found that water was to be had in plenty in the hollows and titree swamps in the sandhill country, and at shallow depths. The swamps were all dry. They only hold water for a month or two after heavy rain. Occasionally we struck a salt bore, but more often good potable water was obtainable, and in quantity. Our greatest successes were obtained in open titree swamps that showed travertine limestone here and there. The so-called springs of the natives were almost invariably in spots of that description. Over quite extensive areas the permanent water-level appeared to be uniform, the sandstone in which the water lies being sufficiently porous to admit of adjustment to a common horizon. It is highly probable that much of the area over which we travelled was in past geological time a vast depression, into which much sediment was washed by flood waters. The channels of those ancient watercourses are now filled with sand, and the present-day flood-waters, soon after leaving the ranges, spread out over the country and are swallowed up in the ocean of sand. The vast depression—or series of depressions—is now nearly filled with wind-blown sand; and the surface consists of a wilderness of sandhills, sand plains, and titree swamps that are dry except for a short time after heavy rains. The porous surface absorbs every drop of rain water that falls, but the sand prevents rapid evaporation, and the water is conserved in the sand and sandstone below. How far one would have to sink through this sandstone to reach bedrock it is difficult to say; but in the centre of the sandhill area its thickness may be, and probably is, great. The quantity of water thus stored away is inexhaustible. Unfortunately the country is a dreary waste, in which food for stock is almost an unknown quantity, except after good rains, when succulent herbage such as parakylia, munyeroo, creepers, and similar fodder grow on the sandhills and plains. But the fierce heat of summer soon destroys it, leaving only an open forest of desert eucalyptus, stunted mallee, and corkwood, and in the north, thickets of turpentine bush in addition. The whole area is covered, and in places densely so, with spinifex, which is for the most part of a very poor quality, and useless for stock. It is a rank-growing variety, having much resin, with a smell resembling turpentine. The white ants (termites) make use of the resin for cementing material in the construction of their tunnels that run

from bush to bush, and in the building of anthills—which, by the way, are a universal feature in the periodically inundated areas. In the clay flats, and more particularly where the flood waters run over the banks of creeks, as for instance on parts of Winnecke Creek, they are built so close together that it was difficult to get our string of camels through without bumping and disarranging the loads. Four, five, and six feet is their average height in such places. The bottom portions of the anthills, in horizontal section, are rarely round, but

mostly oval or lense-shaped, and, as first noted by Mr. Alan Davidson, they are built on Gothic principles. The longer diameter of the section of all of them points in one direction. Their colour is deep chocolate-brown, and but for it they resemble headstones in a huge graveyard.

A peculiar and striking feature, most pleasing to the eye in that land of fearful monotony, are certain stretches of fine large and beautifully green gum trees. As a rule these run along by the sides of the largest sandhills, on sandy soil,

there being nothing to indicate the presence of more moisture where they grow than elsewhere. Beside these gums grow stunted eucalyptus and corkwood. A particularly fine run of large gums occurs to the south of Green Swamp well. They are as handsome as the best salmon gums on the West Australian goldfields, and, like that variety, the leaves shine as though varnished, but the colour of the bark is light grey, not salmon pink.

From the time one leaves the neighbourhood of Hanson Creek until nearing Winnecke Creek, about 200 miles, there are no landmarks. To steer a direct course is a tedious business. The whole country being lightly timbered, no length of outlook is possible. It is only possible to get any sort of view at all by climbing trees, and from them one sees nothing but treetops and gentle undulations to the horizon in all directions. The monotony is appalling. Travel in any direction brings the same landscape. When out of sight of the camp the only sure way of returning was to follow one's tracks back. Finding the anxiety from the possibility of the men missing the camp and getting lost too great, we made breastplate harness for the last camel and made him drag a heavy chain, which cut a small furrow in the ground sufficiently deep to be followed for a month or two after it was cut. The blowing sand would obliterate the furrow in places, but we were always able to pick it up farther on. In the Winnecke Creek country the ground is hardened clay, with shale in places, and if a strong wind was blowing all traces of the pad made by twenty camels were gone in half an hour. The timber, such as it was, grew thicker there than in the sandhills. It was the easiest thing in the world to miss the camp in that country, but the little furrow saved the party from accidents. It was in similar country to this that Anderson and Hitchcock recently lost their lives.

We left Oodnadatta on 17 February 1909, reached Alice Springs on March 13, left for Barrow Creek on the 16th, arrived there on the 28th, and left again on April 3, bound for Victoria river. By travelling in a westerly direction for a few miles we outran the flat-topped line of hills in which lies the Barrow Creek telegraph station, and soon entered a dense mulga scrub, with much dead and fallen timber. The mulga grew so thickly that it was difficult to get through in places, and our track was sinuous, over perfectly level firm sandy soil. From the end of the Barrow Creek hills this mulga-covered plain looked drab and uninviting, and it extended to the horizon in the west and north-west.

We camped that night in the Hanson Creek and next day travelled north for 7 miles along the east bank of the Hanson to an old and apparently dry soakage well in the creek. We spent the rest of the day in getting down to water, which was 9 or 10 feet below the surface. We had to drive in stakes around the hole and weave them with bushes to keep back the running sand, but next day we were able to give the camels a drink from it. The Hanson Creek here has a wide bed of deep sand, and looked promising for a soakage that would last some time, so I decided to timber the well and make it a water that we could fall back upon in case of need. As Paddy had pointed out the site it will be referred to hereafter as "Paddy's Soakage Well." A sea of mulga scrub on level ground surrounds the well for many miles, and no hills or landmarks of any kind are visible from it.

Paddy was rather good at making "mud maps." These are drawn on the ground with a stick, and are the black fellow's way of showing where and how

physical features of interest to him are situated in relation to one another. When requested to show what lay beyond, Paddy drew a map showing the course of the Hanson Creek (the native name is Ahgwaanga), also of the large Lander Creek (native name Allallinga) a good many miles to the west. He indicated certain conspicuous hills near the Lander and the sites of certain springs and soakages on the routes he had travelled, and, by marking his various camps, the time it took to travel from water to water. The production of this map of course took much prompting and questioning. I made a sketch of it which I found useful later on. Some of the "springs" according to Paddy were huge affairs, and one he said had a large open water. Upon inspection they proved to be small native wells or potholes sunk through the travertine limestone, and at the bottom of each perhaps damp sand, or at most a gallon or two of water showing. He was quite right however about the permanency of the supplies, for when we sank wells in the near neighbourhood we invariably obtained a copious supply of good water—as will be described later—and they proved extremely useful to us. A native, in his natural state, only uses water for drinking; it never occurs to him to wash.

On April 9 I took one of the boys and rode out 2½ miles to a small hill from which I took the bearing of any hills rising above the ocean of scrub. A low ridge was showing on 358°, and the boy said that the Hanson Creek ran by the western end of it. He pointed to where the creek ends, on 350°, and to the springs, on 330°. Paddy's soakage well bears 232° from this little hill. The Hanson Creek had always been represented as running north-west, but from our camp its course was evidently much nearer north. The springs were however north-west, but the boy stated that a big soakage existed farther north, down the Lander, and that as the springs were far off we had better go there first, and from there make for the first spring.

Before starting I decided to make Paddy's soakage well as reliable as possible, so we sank it deeper and timbered it well. This took until April 15. On the 16th we started north along the east bank of the Hanson, cutting off the bends when possible. In 5 miles we passed over a hard clay pan, with a little water in it; it was nearly dry. It had a good catchment if rain fell, and there was a fairly good camping ground for either camels or horses on the western side of the creek, which here spreads itself out over the hard ground, but soon becomes more defined. At 10 miles from Paddy's well we reached the ridge above referred to which was composed of bands of quartzite, striking east–west, and dipping steeply both south and north. The ridge has received the name Adieu Ridge, and from it are visible low hills on 96°, high hills (? Mount Strezlecki) on 280°, and a pointed hill on 267°.

Next day we travelled 17 miles, still along the east bank of the Hanson, to Paddy's "big soakage," which we found as dry as a bone, but a freshet near the spot gave us a good temporary soak. The first 9½ miles of the journey were well grassed and clothed with edible spinifex, but the rest was poor sandy country. Some hills 15 or 20 miles north-west of Paddy's well, which I visited later, have been named the Scott Hills, after Mr. F. R. W. Scott of Barrow Creek (the native name is Charra Charra).

On the 19th we made for the first, or nearest, spring, on bearings that varied between 294° and 303°. We crossed the Hanson Creek where it runs north-

easterly, and at 4 miles struck very poor country, timbered with "bastard" box and stunted mallee. We passed over the crest of a sand-ridge, and then travelled in a wide sandy valley between a heavy sand-ridge 3 miles on our left and another 2 miles away on our right. At 7 miles a depression, timbered with limewood and titree, ran north and parallel with the heavy sand-ridge on our left. This ridge now ran diagonally across our path, and at 8 miles we began the ascent of a formidable series of sandhills, crowded close together, the eastern edge of which bore round to the north-west in a semicircle. At the summit we noted in the distance a low-lying circular hollow a little to the right of our course, and Paddy immediately suggested altering our course towards it. After travelling over much loose blowing sand we began the descent to the hollow. It was evident that we ought to have followed a slightly more northerly bearing, and saved ourselves the ascent and tiring travelling over some 7 miles of very heavy sandhills. Down in the centre of the hollow Paddy picked out two natives half a mile away and asked me to stop the caravan while he went down to them. As soon as they saw him approaching they made off for their camp, but halted when he called to them. He soon beckoned us to come on down, and the natives then led us to the first spring, which was in the centre of the hollow. The so-called spring was an oblong hole sunk through the travertine limestone crust into the horizontally disposed sandstone below. The hole was sunk on the incline for 5 or 6 feet, and at the bottom there were about 5 gallons of water. Upon bailing it out we found that the water rose again to the same level, but without a lot of work we saw no prospect of watering twenty camels from it, so we camped and decided to go on to the next spring next morning.

Paddy warned us that poison-bush grew in the sandhills a short distance north, a fact we verified next day. It proved to be a species of *Gastrolobium*—probably *G. grandiflorum*. He stated that it infested all the country along our route from this spring (hereafter to be known as Circle Well, for on the return journey we sank a well close to the spring) to Giant Well, and extended in a wide belt westward to near the Lander Creek. I knew the bush very well, but up to that time had only seen it grow near to or on sandstone ranges in Central Australia, and mostly in small creeks that rise in such ranges. Here I found that the bushes grew on the sandstone hills, on the sandhills, and all over the sand plains as well, and very thickly too in places. A few mouthfuls of this bush and a camel is settled, unless an antidote is administered quickly, and even then it sometimes takes weeks, or even months, before the animal gets well. We had to be most careful of the camels while travelling through the *Gastrolobium* country, and where it grew thickly we tied their jaws together to prevent them snatching bites from the bushes as we travelled along, and we shepherded them very closely while they grazed. I was surprised to find the natives knew the deadly nature of the plant so well. They will not camp under the bushes, and say that if they did harm would come to them. It is evident that the emu can eat the pods with impunity, for the seeds may often be seen in their droppings.

I asked Paddy why the two natives ran away when he was approaching them, knowing that he knew the language and had travelled extensively in the "spring country." He said "they were so sorry to see me come so far alone" (they had

then not seen the camels) "that they ran to their camp to get their stone knives to cut themselves." In that part of the interior every native man has great scars across his thighs, one above the other, between the knee and hip, that mark the sites of deep terrible cuts he has inflicted on himself at different times when some relative has died, or some other great sorrow has fallen upon him. I have occasionally seen natives shortly after they have cut themselves, and the gashes were so deep one wondered that they did not bleed to death. They are forced to lie up for several days afterwards, and go limping for weeks and even months.

On the 20th we started for No. 2 spring. We had not gone far, perhaps half a mile, when the boys pointed out a *Gastrolobium* poison-bush. In 4 miles low sandstone ridges began and continued until we reached 7 miles from camp. Much *Gastrolobium* grew on them. Before we descended from these ridges on to a low-lying valley we saw that heavy sandhill country lay in front of us. The plain, or valley, had low titree growing on it in places. At 6 miles we came to No. 2 spring and some sandhills. From No. 1 to No. 2 spring is 13 miles. Our general direction was north of west, the directions from water to water will appear later on. This No. 2 spring proved to be a shallow native well, in a titree swamp. We sank a large hole a little distance away in sandy ground and watered the camels, the ground being "full of water." The camels were shepherded on the plain and tied up for the night. Poison-bush grew very near the camp all over the sandhills. Next morning we started for No. 3 spring over sandhills thick with poison-bush. In 3 miles we came on a small titree swamp, and in another mile a titree watercourse, or perhaps more correctly a long swamp in the sandhills. There was a native well in it and the water was very near the surface. At 8 miles from camp we came on another titree swamp with a rather large native well in it, at which we camped, with poison-bush all around. On the return journey we sank a well here, getting plenty of good water, and it now bears the name of Fulge Well. This apparently was No. 3 spring, but as a matter of fact all the hollows we had passed, and others for many miles yet to come, appeared to have water in them, very near the surface.

We started on next morning over, and also between, sandhills. In 4 miles we came upon bloodwoods, whitewood, and titree, with poison-bush around, and at 6 miles the sandhills were thick with poison-bush. For the next 2 miles the sandhills were more broken, and then we ran into a flat with grass and low titree, whitewood, and a variety of paper bark new to me. The ground fell away to the north-north-west, the sandhills fell back on either side, and descending on to a flat we were gladdened by the sight of clumps of beautiful green wattles, and in one clump was a native well. This well was a hole, 2 feet 6 inches in diameter, sunk through a travertine-limestone crust, that widened below into the dimensions of a fair-sized round galvanized iron tank, with water showing about 4 feet below the surface. I tried to get the boys to go into the well and clean it out, but they said a huge snake lived in it, and nothing would induce them to get into the well. I had to get in myself, the boys watching meanwhile to see the snake make a meal of me. We cleaned out the hole and watered the camels from it, and it now bears the name of Wattle Spring. The flats around grew samphire, and the camels grazed thereon with apparent relish. They eat the wattle also and fared better at this camp than for some time

past, having had to be shepherded very closely to keep them from eating the *Gastrolobium*.

Next day, April 23, after watering the camels, we started for Paddy's "big spring." We travelled first over the plain, which was covered with samphire, and on which water lies for some time after heavy rain. These conditions lasted for 3 miles. A mile and a half from Wattle Spring we passed a native well, with water showing at 4 feet 6 inches below the surface. At the plain's end we struck and had to cross on the angle some steep sandhills, and at 4½ miles were in a perfect jumble of sandhills. From the top of these we could see a heavy sandhill about 3 miles away on our left. This extended to the west-north-west, where a tableland continued on to the north-west broken by a gap right on our course. We ran down a sandy slope into a deep hollow that lay between us and the tableland. At the bottom we came to a shallow watercourse that ran south-east across our route, with a clump of wattles in its bed in which was a shallow hole with a little surface water. A hundred yards or so to the south-west was a native well, in sandstone that outcropped in the watercourse. The water was only a couple of feet from the surface, perfectly fresh, and the supply inexhaustible, as we found when making the native well into a proper well at a later date. It is an unfortunate circumstance that that portion of the so-called "spring country" through which we had just travelled is practically useless for stock, being not only a wilderness of heavy drifting sandhills, but, what is far worse, also infested with the poisonous *Gastrolobium* plant. On the sandy slope to this water, now known as Giant Well, we saw the last plant, and the natives assured us that this is its northern boundary. Had the "spring country" been only moderately-well grassed and free of poison-bush, it would have been of considerable value, for fresh water, at very shallow depth, is obtainable in every hollow between the sandhills.

From an eminence near Giant Well I obtained prismatic compass bearings of high hill on the Lander, 191°. It appeared to be 60 or 70 miles away. Scott [illegible]s, 151½°; Mount Denison (or what I took for Mount Denison, on the [illegible]nder), 184°; Mount Strezlecki (?) 121½°; and the end of the Lander, according to the natives, 347°.

We reached Giant Well on the 23rd and remained there the following day, enlarging the well, watering the camels, and making up the map to date. On the 25th we started for the last spring that Paddy had seen. In 1 mile we crossed [illegible] sandstone outcrop, and half a mile beyond that we passed a quartzite quarry [illegible]re the natives manufacture their stone knives. At 2 miles we passed, to the [illegible]th of our course, a spot with wattles growing around, where water evidently [illegible]ts very close to the surface. At 2½ miles we crossed a low watershed, and at 3 miles some small clay-pans. To the north and north-west were flat-topped sandstone ridges. Sandstone outcropped in places along our route, which was timbered with a line of limewood gum trees, wattles, and titree, with grass in places, and spinifex with edible tops. I have not mentioned spinifex much so far in this record, but it is omnipresent in this part of Australia, on the sand plains and sandhills, in the hollows, on the rocky hills; in short, it is ubiquitous. The sandhills seen from near Giant Well, to the south and south-west, ran on north-westerly in a continuous line, and were now not far from our route. At 6 miles from Giant Well we came to a sandstone ridge, and running north-west from

it was a small watercourse, with a native well in it. From the highest point of the sandstone ridge the well which we sank here bears 295°. It is now known as End Well. It is about one-third of a mile from the ridge. On 292° are the tops of two sandstone rises. Limewood gums continue on to the westward of End Well. We were hoping for some hills, or some distinctive landmarks, along our course—which was north-west—but the outlook from this sandstone ridge was not hopeful. On all western points right round to the north-east was a perfectly level horizon, a sea of sandhills as far as the eye could reach. We appeared to have come to the limit of the sandstone formation which first outcropped near Circle Well. Geologically I take it to be younger than Adieu Ridge on the Hanson, which may be pre-Cambrian. This sandstone formation is, in my opinion, of Palaeozoic age, and may be Cambrian. It is much fractured and disturbed in places, though its general disposition is more or less horizontal.

End Well being the end of everything so far as Paddy's knowledge went, we now availed ourselves of the offer of several natives who had come to visit our camp, to show us a spring they knew of bearing north-north-west. It is quite impossible to keep on a given bearing when following a crowd of natives who are hunting rats, cats, lizards, etc., on the march. They spread out in crescent form, and throw boomerangs at anything they disturb. It is little use the animal trying to escape, for some boomerang is almost certain to hit it. If it elects to crouch in a bunch of spinifex, as the cats often did, it is speared. On this march, and on several other marches, we saw the wonderfully accurate way in which a native can throw a spear. In almost every case the spears went through the animals. This country was so thickly stocked with rats and cats that at the end of the day's march a great number would be brought into camp by the natives, and my men named it, and afterwards referred to it, as the Rat and Cat Country.

On the 27th we started from End Well, following the natives first north-west, then north, north-east, and east to a hollow surrounded by blowing sandhills, the floor of which was a crust of travertine limestone, or perhaps more correctly, calcareous sandstone, through which was a hole several feet long and 5 or 6 feet wide. The native well was sunk in sandstone below this crust for 3 or 4 feet to water. I calculated the distance from End Well straight to this water-hole at 14 miles, but the route the natives had brought us was very circuitous. For the first 3 miles the country had grass—fair pastoral flat land. There were low sandstone rises on our left, then low sandhills to 7 miles, and a little farther on a quartzite outcrop, and a hollow in which grew whitewood gums. This continued for $1\frac{3}{4}$ miles, when we entered a sandhill country, the sandhills running east and west, and continuing to the so-called spring. All the way was sparsely timbered, and as we neared the spring sand was blowing. The spinifex *en route* grew tops. The next two days we spent here, sinking a well for 6 or 7 feet in the sandstone below the crust, but the supply not being sufficient for our needs we bored in the bottom a few feet, when a good supply of fresh water rose 5 feet in the well. It was a desolate spot, and the well is named the Hit or Miss Well.

On the 30th we started for another so-called spring to which one of the natives had agreed to pilot us. This lay north-westerly from Hit or Miss Well. Soon timber appeared on our right. At 3 miles a titree hollow, and our guide said there was water on our left, but we did not see it. At $3\frac{1}{2}$ miles we passed

a native well in sand; but there was no water to be seen in it. At 5 miles the edge of the timbered country was on our left; it consisted in part of bloodwood and limewood. A long low rise with a flat top was visible from here to the north, perhaps 5 miles off. At 6¼ miles the ground was strewn with brown ironstone rubble. At 8 miles we were on the top of a slight rise, with a hollow to the south, and another to the north, the latter rather pronounced. Then came bloodwoods and limewoods, the timber getting more open as we travelled along, and a small grassy flat close to camp. Davidson's track, so the native said, was near this camp; but the blowing sand had obliterated all trace of it.

Next day, May 1, in 2½ miles we had passed over the rise and were in a depression which ran round like a horseshoe to the west of us, and where we crossed it a few limewoods were seen. In 3 miles we were on the top of a rise, with a hollow to the north. We then ran along a mallee-timbered rise for 2½ miles, and then through a depression, with mallee. At 9 miles from starting we passed out of the mallee and entered a thicket-like scrub consisting of green sticks, used by the natives for spears, and the bark and leaves of which resemble wattle. As we approached some sandhills the undulations grew shorter. A very poor country all the morning for stock feed. At 10 miles from camp we came on the first of several sandhills; at 10½ miles a dry native well. At 14 miles we camped, in a fine run of limewoods, which ran along under the northern lee of high sandhills on our left. From the native well to camp titree grew between the sandy rises, which appeared to end here; but on our left there appeared to be a vast tract of sandhill country.

On the 2nd, in 3 miles from camp in limewoods, we passed out of timber and then over a low saddle. Here there was a thicket of the hard sticks, like wattle, on our left, and rising ground on either side. At 4½ miles from camp the sand and sand ridges fell away, and we ran down to a titree-covered lowland. In the far distance, north-westerly, there was visible what might be a tableland, or perhaps sandhills. At 5½ miles I noted a patch or two of travertine limestone on the plain. Here and there a solitary limewood grew, with semi-thickets of the hard wattle, and titree. These features continued until we arrived at the so-called spring, which was 6½ miles from camp, and 32 miles from Hit or Miss Well.

This native well was in a thicket and the water was in a hole, or cleft, in travertine limestone. After some work we succeeded in watering most of the camels from it, and then we tested the ground by boring, in a more convenient site. On the 3rd we started a well on the new site, and finished it next day. Notwithstanding that it was winter we had a couple of roasting-hot days here. The well is in a titree swamp. There is a green swamp with samphire and other camel feed surrounding a red sandhill a short distance from the well, and from this delectable spot the well derived its name, Green Swamp Well. Like all the others along the route, it is shallow and yields a good supply of excellent drinking water. There is a little grass in the low-lying swampy area here which, by the way, is of some size, and the camels found much better feed here than at most of the camps since leaving the Hanson. The only other grassy stretch is from Giant Well to End Well. Travertine limestone is visible in several places over the Green Swamp hollow and doubtless water in endless quantity lies beneath all over it at very shallow depth.

Davidson's Duck Ponds, on Winnecke Creek, were our objective when we started out from Green Swamp Well on the 6th on the bearing 312°. Mallee began near the well. At 4 miles we topped a long sand-ridge that had been on our right. From the well here there had been grass and spinifex tops, fairly open country. From the crest the great hollow we had just crossed was conspicuous. At 7½ miles from camp the ridge we were on, of nearly flat firm sand, appeared to be rising to the south-west and falling in every other direction. There were sandhills to the north-east in the distance, and lower ground on all the northern horizon. At 10 miles we were on a high sand tableland, with a heavy depression on our left running round in front of us; the bottom of the hollow appeared to be about 5 miles away. The land was falling on our right also, with sandhills showing 2 miles off.

At 12 miles from Green Swamp Well we camped. There were several trees resembling the paw-paw tree about the camp. Next morning we continued on the same bearing, and in one mile were in a hollow that trends east and west. At 2½ miles we were on top of a sandy ridge. Corkwood—always present in desert regions—was the dominant timber of this part. At 3½ miles there was a hollow to south-south-east, and apparently a titree swamp. Sand rose all along the southern horizon. We could see 20 miles. To north the ground was rising. At 13 miles we camped. For the last 10 miles the land was gently undulating. For the last mile or two there were a fair number of paw-paw and bloodwoods, of the mallee type. A poor variety of bloodwood was seen all day, and clumps of mallee. Along this march the spinifex had been recently burnt, and the ground was a charred mass of low sand heaps. The heat was oppressive all day.

On the third day out from Green Swamp Well, April 8, we started still on the bearing 312°, and ran down a long depression between two lines of sandhills a good way off the line of route. At 6 miles we struck a box swamp and then marched for 4 more miles on the same course, skirting, on the north, a thick scrub. Titree now became plentiful, and spinifex very dense. We turned west-south-west for 3 miles, and again to north-west for 1½ miles, then camped. This third camp from Green Swamp Well was a poor one for the camels. Next day we returned to the box swamp seen yesterday and sank a borehole 9 feet, but got no water. The sinking was hard, so we decided to return to Green Swamp Well, water the camels, and try a more southerly route, as the one we were on was on comparatively high ground. Next day we returned along our outward pad and camped 13 miles north-west of Green Swamp Well. On the 11th we reached Green Swamp Well. The camels had been six days without water, save a couple of buckets we gave each from what we carried. We spent the next two days putting a set of timber around the mouth of the well, and mending saddles. A black fellow, who with his wife and two children visited Green Swamp Well, reported that a native well existed on the bearing 280° from the well, and another on 216°. He promised to take us to the former after he had visited the latter, but failed to turn up as promised.

On the 14th we started on our second try for water on 280°. In 4 miles the sandhills fell off and we entered a plain with desert mallee, and at 6 miles a low sand ridge appeared on our right. At 8 miles the poor timber grew sparser, and the country was very poor. Higher country appeared to lie to the north and

north-west. At 13 miles we camped in hedgewood, with not much feed, and the camels were inclined to wander. A good many trees, resembling the Moreton Bay fig tree, grew about this camp. In the evening I noticed Tim, the black boy, making a stone pick, which he said would be a good fighting weapon. Next day we found that both our black boys had decamped in the night. The camels had wandered far by the time we overtook them—the boys usually brought them back each morning—and it took the whole day to get them together.

We now travelled 7 miles on the same course as before and camped on a burnt patch that grew a runner-plant that the camels seemed to appreciate. It was green and succulent, but there was not much of it. The whole area was one of sand, in long undulations culminating in a sand ridge every 3 or 4 miles. It was terribly desolate country. I decided to leave the camp where it was and take Baxter and three camels and prospect ahead for a day or two. So on the 17th we started on 280° over sandy country clothed with tall mallee, then along elevated land with here and there patches of Moreton-Bay-like trees. We then turned due south, and at 6 miles were on the top of a high sandhill. To the west-south-west was a hollow, with rising ground in the distance. South-west the landscape was similar, and we could see no change for 30 or 35 miles. To the south and south-east were big rolling red sandhills as far as the eye could see—a most hopeless outlook for 15 or 20 miles ahead. This was the worst of many bad places we got into in searching for sites to bore for water. We travelled 1 mile north and camped.

We saw the tracks of two natives while travelling, but failed to find their water. On the 18th we travelled straight back to where the party were camped, and on the way saw a flock of grey top-knot pigeons, so there must be some surface water about. On the 19th I took Baxter and two riding camels to try and find the water the pigeons were drinking from. We first went east, then south-east, then south-west, then north-west back to camp, which we called Pigeon Camp. At the farthest point out we saw some gum trees, but failed to find the water.

The camels, having grazed on the runner-plant, were not yet very thirsty, so I decided to take the whole party and try the country between the two outward routes. We travelled on 50°, over a "blowing-sand" area with heavy undulations, the whole way. We got a surprise at $3\frac{1}{2}$, and again at $4\frac{1}{2}$ miles from Pigeon Camp at seeing the tracks of one bullock. At the latter distance we dropped on to a plain; at $5\frac{1}{2}$ miles we were again on top of a high sandhill from which we saw a titree swamp a mile and a half to the north. We went to it, decided to bore, and at 9 feet 6 inches from surface struck a fair supply of fresh water. We then started a well and got down 2 feet on this day also. Next morning we found that the water in the borehole had risen to within 3 feet of the surface. We worked with a will, for the camels had been without water for eight days, and were thirsty, and by 11 p.m. finished watering them. The well is named Cattle Swamp Well, and from it the high sandhill from which we first saw the swamp bears 197°. A big red sandhill bears 177°, and a small hill in the far distance with a peak top 327° (doubtful).

On May 23 we started on the bearing 327°. At $2\frac{1}{2}$ miles we came on two small titree swamps in low sandhill country, then an open plain; at 5 miles

more sandhills, which ran about east and west. As we crossed these I saw, on a small plain between the sand-ridges, several mounds of rock 4 and 5 feet high, amongst the limewood gums that grew on the plain. To see rock outcropping through the sand was most unusual. Ever since leaving End Well sandhills and sand plains had prevailed. I did not go over to these mounds, but took them to be formed of grey limestone. The sand-ridges were four in number, and at 6 miles we were through them. From the last one we saw, to the south-west and west, belair scrub and flat country with bloodwoods growing over it. A little north of the last sandhill was a titree swamp, that ran parallel with the sand-ridges, and over the level ground around limewood gum trees were scattered. Then followed another sand-ridge, and again at 8 miles from Cattle Swamp Well another run of titree swamps parallel to the sandhills. On this No. 3 titree swamp we camped. We saw a good many gallahs and white cockatoo parrots with pink breasts in the sandhills 4 miles back from camp. Limestone outcropped in many places between the sandhills we crossed on this march. The limewood gums and the bloodwoods were large and looked fresh and green from the tops of the sandhills. From the turkey and emu tracks that we had seen and a bullock track only three or four days old, we concluded that there must be surface water about. The country also must be low-lying, for titree swamps were numerous.

On the 24th we continued on the same bearing, 327°, over recently burnt country. The firm sandy surface was gently undulating, and clothed with very open titree scrubs and a poor desert variety of box. The ground grew harder as we proceeded and looked as if it were swampy and boggy during heavy rains in the rainy season. It looked poor land, with little or no grass, but the fact that the whole country had been burnt made it difficult to judge. There were low sand-ridges on our right. At 10 miles there was a sandy rise, and at 12 miles we had to bore our way through belair thickets, and ironstone pebbles covered the surface. We ran down a steep slope into a grassy watercourse and camped in it, at 14 miles from the last camp and 23 from Cattle Swamp Well. The watercourse was simply a grassy flat—not a creek. It had one bunch of mulga in it—the first mulga we had seen for a long time. There were plenty of limewoods, well-grown corkwoods, belair, wild rose bushes, and a variety of wattle on both sides of the watercourse. The prospect was quite pleasing when compared with the dismal surroundings we had been in for so long; but the grass was dry, and it was a terribly dry time here. There was rising ground to the west and south-west, and in front of our course a distinct rise—almost a hill.

This sandhill tract of country gave me the impression that at one time it was a vast hollow, before utter desiccation set in, and may have been filled with water. The Lander poured its flood waters into it, and possibly the Hanson and Winnecke creeks as well. In addition to the sediment brought into the hollow by flood waters, very much larger quantities were transported thither by wind. This latter agency may not have been so active at first, but in later time, and right on to the present, wind has been the major transporting agent in filling the hollow. It appears to be nearly filled at the present time. A remarkable feature of many of the hollows on its present surface is the continuous water horizon lying very near the surface. This is frequently indicated by a crust of

travertine limestone of varying thickness which probably was formed when the water-table rested sufficiently near the surface for moisture to be drawn therefrom to the surface and evaporated by the sun's heat, leaving its lime content as a precipitate in the sandy surface layer, in which it has acted as a cement, and formed a crust. It is evident, from the fact that the horizontal limestone crust runs away under the giant sandhills in places, that the sandhills are encroaching on the hollows. It is possible also that on the opposite, or north-western, side of the hollows the sand may be travelling away and leaving further flat moist surface areas on which a limestone crust can form.

In some of the wells we sank we found more than one band, or layer, of limestone, which pointed to a gradually rising water-table—a thing quite possible where a hollow formed of impervious rocks is filling with sand, on which there is a fairly good annual rainfall. As the rain falls here it immediately sinks into the sand and, percolating downwards, reaches the water-table. It is only in the hollows that the water-table is sufficiently near the surface for evaporation to take place and, incidentally, form limestone crusts—a process that has been going on for ages past, and is likely to continue for ages to come. Herein lies my explanation of the quite phenomenal long line of shallow permanent waters we met with between Barrow Creek and Victoria river. Without the covering of sand the water would have been evaporated long ago, for the average annual precipitation over the area is 10 to 12 inches only, while the evaporation is not less than 12 feet.

At this, Wild Rose, camp a distinct change had taken place in the geology of our surroundings. Sandstone and shale, with ironstone conglomerate, underlay a thin sandy surface, down through which this blind watercourse had cut its way in long-past ages. The geological age of the shale formation we had now reached is uncertain, but it is evidently much younger than the sandstones between Circle Well and Fulge Well, and between Giant Well and End Well. Lithologically it bears little likeness to anything near Barrow Creek. It forms the north-western edge of the sand-filled hollow we had just crossed. It continues from here north-westerly to Victoria river. I believe it to be older than the basalts of Victoria river, the Great Antrim Plateau, and Renner Springs, near Powell Creek. It bears a close resemblance to the shale formation that occurs between Banka Banka and Renner Springs, on the Overland Telegraph Line. It may belong to one of the younger Palaeozoics, or even be one of the Mesozoics. Between Wild Rose Camp and Victoria river it gently undulates. The wide trough-like hollow in which Winnecke Creek runs cuts deeply into it. The formation varies in character, being for the most part dark purple in colour, and is composed of layers of sandstone, massive for the most part, but occasionally flaggy. Thick bands of shale and bands of haematite are striking features in several localities. Bands of conglomerate also occur in places. These rocks gently undulate, but they are not greatly jointed or disturbed, at any rate "regionally." Evidently, by the colourings on his map, Davidson regarded the Buchanan Hills as of this formation. He was probably right. The best sections seen by the writer were along the course of Winnecke Creek. The strata there are mostly of ferruginous sandstone, horizontally disposed—thick flaggy layers with which much haematite is associated. Back from the creek for considerable distances, especially on the north side, the ironstone forms small hills at Ross Gap.

On the 25th we left Wild Rose Camp and proceeded on the same bearing, 327°. Limewoods continued for 1½ miles. After a gentle rise for 7 miles a slight fall was apparent to the north-west. The country was fairly open and covered with spinifex, but no grass. At 11 miles from camp a low line of red hills was visible to the east. The same may be a continuation of the "conglomerate hills" of Davidson, for our lines of traverse converged here and continued so to Winnecke Creek. The gradual descent continued to 14 miles, where we made camp. Turpentine bush grows all over this shale and sandstone formation, sometimes singly, but mostly in thickets. This vile sticky bush has taken the place of other bushes to a large extent. Instead of the soft sand we had travelled over for so long, this day we had hard red sandy soil all the way, the camels scarcely making a mark on it. As we travelled over it the ground looked perfectly flat: it was only in the distance that an incline or decline became apparent. From our camp rising ground was showing to the north-west, a good many miles away. The most conspicuous portion of the low conglomerate range, or rise, for it was not a conspicuous feature, bore 97°, but the outline extended along the horizon from 80° to 105°. The range appeared to be 4 or 5 miles away.

On the 26th we left Conglomerate Hills Camp, continuing on bearing 327°. Scrub gave place to open country, and a ridge 1½ miles on our left completely shut out our view in that direction. At 5 miles we seemed to be on the top of a dome with a wide valley between us and the conglomerate hills. At 8 miles, when passing over a bare patch of shale, I was surprised to find a hole, like a round well, going straight down into the shale for 20 or 25 feet and then a passage led off horizontally. All the rain water caught on the bare shaly patch of rock ran into the hole and from it into the underground passage, making thereby a short cut to lower levels. The sides of the hole were waterworn and smooth. We did not descend it to explore the passage but passed on, and at a quarter of a mile from the hole a conspicuous landmark, in the form of a small cone-shaped hill, showed up on a bearing of 233°. The hill appeared to be 8 to 10 miles away. Davidson saw, but did not name, this hill, so it now bears the name Lothario Hill. This is the only conspicuous landmark we had come across for many a day. Those who have not travelled over a tract of country of such dimensions, absolutely devoid of conspicuous landmarks, can hardly understand how dreary travelling becomes, and how monotonous, when surrounded by low scrub that shuts out the view in all directions, pushing a way through them day after day and week after week, with not a sound but the pit-pat of the camels' feet on the ground, and the creak and groan of their loads, as they stalk majestically along. Surroundings like these are productive of sensations that incline to the serious. The lives of the whole party depend on making no mistakes. The success or failure of such journeys depend on knowing how to handle the camels and on being able to judge accurately how far each animal can carry the load assigned to it without a drink. Our camels were good and sound. My companions were loyal, and I never heard one word of fear, or a complaint, from any of them, and so we got along well, and each day brought us nearer our journey's end.

The sight of a hill put new life into the whole party, for we now knew that Winnecke Creek was not many miles away, and that there was a chance of

finding water in some of the water-holes along its course. From the peculiar hole we ran down a very gentle slope and camped in a belt of rather well-grown bloodwood timber. The low ridges we passed over on this day's march, inclusive of the one with the remarkable hole, were capped with ironstone conglomerate. The sandstone and shale formation occupies the whole country, although often hidden by sand on the gently inclined slopes and hollows; the strata lying for the most part quite horizontal. From the rock-hole eminence the horizon-line to the north-east looked like a low broken tableland, and rising ground extended right round from east to south-west. The ridge on our left fell away and a valley succeeded, which appeared to run parallel to our course. It was beyond this valley that the cone-shaped hill stood out plainly. Although quite a small hill, it was, I repeat, the most conspicuous landmark seen since we left the hills near Barrow Creek. It impressed us greatly, being such a contrast to the gentle rises and hollows that obtain in a country devoid of any striking physical features. Monotony is the dominating characteristic of Central Australian scenery.

On May 27 we left Bloodwood Camp and continued on 327°. We had practically level country for 5 or 6 miles, timbered with mallee, box, belair, turpentine—scrub the whole way; then gently-rising ground until 10 miles from camp, where ironstone conglomerate formed the surface. The flat land here terminates suddenly, and there is a steep descent for 1 mile that runs down to the Winnecke Creek, the spot being about 5 miles north-easterly from Duck Pond water-hole.

From the top of the ridge that overlooks the Winnecke Creek the box timber in the valley seemed green in comparison with the sombre surroundings. This part of Winnecke Creek is peculiar, as one may cross its bed in places and not know that it is a creek. In its upper part it is a well-defined and sandy bedded watercourse, but here in places it is simply a grass-covered flat, with nothing to show the direction in which the water flows. An occasional scraggy box tree however marks the course of the water. The creek rarely gets flooded throughout its whole length, but it is evident, from the occurrence of large water-holes at intervals of, say, 1 to 3 miles, that great floods occur sometimes. By following along the grassy flats one comes upon the end of a tiny rivulet, which soon increases in size until it forms a creek, leading down a gentle slope to a water-hole. Several of the water-holes are of considerable dimensions and hold water for several months when filled. The watercourse on the other side of the water-hole gradually diminishes in size, finally ending as it began, in a grassy flat. On following the grassy flat still farther one finds that the whole thing is repeated. In this way several very good water-holes occur. We hit the creek right on one of these washouts. It was a quarter of a mile long, and in the northern end were two pools of water in the bottom of holes 10 feet deep. Only 18 inches of water remained in this water-hole, which is not one of the best in the creek. The water was sufficient for our purposes however. This and some other of the holes have conglomerate bottoms, and hold well. The ground along the creek and the grassy flats is hard clay, and as each water-hole has a good catchment area of its own, the holes get filled whenever a good shower of rain falls. I would not consider any of the holes I saw as permanent waters, but they hold for a long time after the summer rains, and in one water-hole there is a soakage to be had long

after surface water has gone. Farther up the creek at Ross Gap there is a good soakage in the sand. It had water each time I passed there, but whether permanent or not I cannot say. Excepting the small pool at Giant Well this was the first surface water seen since leaving Barrow Creek. From Bloodwood Camp to Winnecke Creek was 11 miles. We camped at the water.

We remained at Winnecke Creek the following day, May 28, to allow the camels to feed, but next day we started for Victoria river. We first made a slight detour easterly to escape some thick scrub, and to take advantage of a long valley that ran north to obtain good travelling for the camels. At 6 miles from Winnecke Creek we saw a large expanse of bloodwood to the south-east on a plain, with dark foliage in the distance; at 8 miles a deep valley on our right, with green trees in the hollow. Our bearing was now 360°. At 10 miles we struck a black line of timber, which was composed of native orange, supplejack, creepers, etc.—splendid camel feed, but there was no creek. Here we made our camp. We had had exceptionally heavy spinifex for the last 2 miles. The ground is here so hard and dense that when heavy rain falls the country swims with water. The spinifex grows in great bunches 4 feet high and several feet across at the base, forming quite a formidable obstacle to travel.

On May 30 we continued on same course for 2½ miles, then changed to 315°. We first crossed a grassy and splendidly bushed plain, subject to periodical flooding in the rainy season, then a depression, and then more open country that resembled a water-parting. At 6 miles a little travertine limestone appeared on the surface for a mile. At 8 miles we were in a bloodwood and gum-tree valley, and at 10½ miles bush came in, with level ground to the west and a ridge 2 or 3 miles off on our right. At 15 miles we camped on a water-parting, with box and mallee around.

Next day, still on the same course, we first crossed a depression, but after 5 miles spinifex gave place to grass for 2 miles, then well-grassed timbered and bushed country followed. For 5 or 6 miles we travelled over an older rock formation than the purple shale of the tableland. This older series had undergone considerable disturbance. Slate and shale formed the tops of the rises, while limestone succeeded below. There were outcrops of limestone at intervals, and the surface was strewn with pebbles of slate, shale, quartzite, sandstone, and limestone. A great view was obtained from the hillocks, extending right round the horizon, except to the north and north-east. We passed out of the limestone and bloodwood area at 11 miles. From 11 to 12 miles there was a fine grassy plain with stunted box timber, then spinifex as thick as ever to 14 miles, and we camped at what we afterwards referred to as Corkwood Camp.

On June 1 we were still on the same course through mallee, corkwood, and dense spinifex country. At 6¼ miles we crossed a run of paper bark trees, quite a new feature, then poor country to 12 miles, where we were down in a hollow, with a little grass and a horse pad showing. At 13 miles we camped, having passed over a grassy swamp for the last mile. Here we saw a cat and a quail, and horse and cattle tracks.

Next day we travelled on the same bearing and in half a mile came on more new cattle tracks; at 2½ miles we were on a rise strewn with ironstone rubble, and at 5 miles on a slope that led to a creek, which we reached in one more mile.

We followed the creek south-east for 6 miles and then camped, but all the water-holes in it were just dry. Cattle tracks and pads were numerous. Next morning we travelled back along the same pad we came by to the point where we first struck the creek, then for 2 miles on 257°, and, seeing cattle about, camped, thinking their watering-place must be near; but we failed to find it.

On the 4th, taking Baxter with me and a couple of riding camels, I went west-south-west along the course of creek and found some shallow clay-holes with water, where the cattle watered. The water was pretty muddy, but drinkable when cleared. The rest of the team arrived later, and we camped. We stopped here two days and then started on 207° for 5 miles, then on 10° for 4 miles to the head of a creek, which we called Horse Creek. We followed it down a steep descent, over many ledges of sandstone, slate, and basaltic-ejectamenta rock, and camped. We had now reached the southern edge of the large basaltic area of Victoria river. The tableland here breaks up into a number of isolated flat-topped hills, remnants of a partially eroded tableland.

Our way now led nearly north over rough basalt country to a small creek near two hills, called the "Sisters." They are not far from the Camfield river, a tributary of Victoria river. On June 9 we first travelled on the bearing 10° and in 1 mile struck a fairly large creek and followed it down for 11 miles; it ran about due east. Later we found it to be the head of the Camfield river. We then followed the tracks of a newly shod horse, driving cattle, for 2 miles, and then camped. We had passed by many water-holes on the way and numerous billabongs on the sides of the main creek, which was lined with large box-trees and guttapercha. All the previous day and this we passed through basalt country splendidly grassed, but we saw no water. After making camp I walked north-north-west to a hill, and from it saw a table-topped range to the north-west a few miles off.

Next day we travelled on the bearing of 328° for 2½ miles, then on 338°, and at 4 miles were on a watershed, with the four prominent hills of the range in sight. We then travelled on 311° to the south point of these hills and camped, at 13 miles from our last camp. Upon climbing to the summit I was pleased to find that the hill was one of Mr. L. A. Wells' trigonometrical stations, named South Point. The Adelaide Survey Office had very kindly given me, just as I was leaving Adelaide, the first rough pull of Mr. Wells' map of Victoria river and district, on which this trigged hill was shown. We were now aware of our exact position—a few miles east of Wave Hill cattle station homestead on the Victoria river. As we had left Barrow Creek on April 3 the journey across had taken ten weeks all but one day.

On June 11 we travelled south-west straight for the Croker Yards, and in 1 mile after starting met Mr. Seale, the manager of Wave Hill cattle station. He seemed to be greatly surprised at the size of our caravan. I was pleased to accept his cordial invitation to visit the station. Wave Hill at that time carried about 70,000 head of cattle, and the adjoining station—Victoria River Downs—about 120,000. The splendid pastures and magnificent water-holes of Victoria River are too well known to need commendation from me.

The Return Journey

Our outward route north from Winnecke Creek to Victoria river had been too far east, so on the return journey we first travelled to Mucka, an outstation of Wave Hill, to get a supply of salt meat, and then to the big bend of the Victoria river, the most south-easterly point on the river, at the Catfish Water-hole and Yards. It was from this point that I wished to open up a stock route as nearly direct as possible to Central Mount Stuart. Both Davidson and ourselves had failed to find Hooker Creek, and the inference was that it lay farther to the west than we had reckoned. I decided to try and locate a water-hole on that creek, and also a billabong a few miles out from Catfish Yard with the delightful name of Warcurracurra. A native woman was prevailed upon by the chief stockman at Mucka to pilot us there.

On 25 June 1909 we started, first following up a small tributary of Victoria river to its source, the edge of the tableland, 8 miles south-east of our starting-point. The tableland scarp is continuous, and too steep in many places for a string of loaded camels to surmount. From the edge of this tableland our course, although somewhat sinuous (for the native woman's route was "go-as-you-please," as is that of all natives) was nearly east, for 6 miles, where we struck the water. The billabong was a long wide clay-hole in a small creek. It is not a permanent water. When we left it perhaps 18 inches or 2 feet depth of water remained. It was of no use for my proposed stock route. It lies about south-east-by-east from Catfish Yard, and 14 miles away. From the edge of the tableland all the country from east round to south was clothed with spinifex, mallee, box, supplejack, peach, whitewood, and currant bush. Although practically a desert, I was assured by the cattle men of the country that the stock having access to the bush country seemed healthier and to keep in better condition than those that grazed only on the lovely grassy plains that border the Victoria river and its tributaries. The dividing line between the two totally unlike classes of country is here the escarpment of the tableland. In five minutes one passes from one to the other. The basalt soil is good—very good. The soil derived from the shale and ferruginous sandstone is poor for grasses, but it grows edible bushes for stock and timber, and for that reason cannot be classed as "desert." But travellers invariably speak of it as such. The so-called tableland country extends along the route we followed from a little north of Cattle Swamp Well to Victoria river, and in an easterly direction probably to Banka Banka Station and Renner Springs on the Overland Telegraph Line, as previously mentioned. According to Davidson extensive areas of it occur to the south-west, and run on to well over the Western Australian border.

From Warcurracurra it was necessary to go on a bearing a little west of south to try and locate the water-hole and billabong which rumour placed on the eastern end of Hooker Creek. On June 26 we bore away on 192°. At $4\frac{1}{2}$ miles we crossed the eastern end of a ridge capped with quartzite and ironstone. This ridge forms the watershed of Warcurracurra Creek. The southern slope beyond showed indications of considerable flow of water at times, but we saw no creek. There grew on it high coarse grass, and giant mallee and box, the drainage being towards the south-west or west. Then more spinifex and mallee, then more rises close to the route on the east side, and at 10 miles we crossed a

small ridge, then mallee scrub and turpentine on and off until we camped in plumbush at 14 miles from our last camp.

On the 27th we continued on the same bearing, 192°, and soon were running along the western end of a hollow that ran to the east; along this watershed we travelled for 4 miles, then over a flat-topped tableland and down a slope, crossing a grassy swamp, followed by spinifex and mallee, and at 6 miles from Plumbush Camp struck gum trees and the edge of a broad grassy plain, on which for 2 miles the grass grew very high, evidently a flooded area in the rainy season. It proved to be the overflow of Hooker Creek. After crossing this overflow we returned to the gums and camped, the camp being 20 miles from Warcurracurra. After lunch I went down the watercourse and found no water, but the men found it in a water-hole 1½ miles up the creek, west of the camp, in the grassy watercourse. It was of fair size, but not a permanent water.

On the 28th, after watering the camels, we started along down a branch of Hooker Creek that runs east on the whole but winds about a lot in its course, and in 5 miles we camped on the creek, which was quite a small affair, in a series of swamps. Next day, still following the creek for 7 or 8 miles, we passed a water-hole, just dry, named Two Dog Water-hole (as there were two wild dogs there) and crossed a swampy area on the way. At 8 miles the creek was evidently getting smaller and appeared to be losing itself in swamps, and as its course was too far north to follow any farther I changed to 132° for 7 miles and camped in corkwoods, having travelled 15 miles for the day. On the way we had a serious capsize, and several of the camels got rid of their loads. We tied the camels up that night as they would not stay, and started next morning without letting them go to graze. We had open level sandy burnt ground from the time we started on this bearing, timbered with a few scattered corkwoods and mallee. Next morning, on the same bearing, in 1 mile the timber changed to bloodwoods, which soon changed to larger bloodwoods, and gum trees came in, giving the appearance of a creek at hand. There was camel bush here also. This continued to 4 miles when, upon meeting with really good camel bush, supplejack, and several other varieties of creeper, we camped for the day to give the camels a good feed. We had had level ground from the Hooker Creek big swamp all the way to here.

On July 1, still on 132°, at 3½ miles we were out of the good camel country and into scattered bloodwoods. A low dome on our course was just visible. At 7 miles we were on this rise, with ironstone conglomerate and ironstone rubble all over it, and at 8 miles the Buchanan Hills (of Davidson), a remnant of a former tableland, came into view. A cone on the north end of the tableland bore 187°, and the centre of the tableland 184° from here. No hills were visible in any other direction. At 12 miles we passed between two little hills. At 14 miles Buchanan Hills were full in sight, and the pointed hill at the north end bore 209°. We made camp near here among creeper, supplejack, and all sorts of camel bushes.

Next day we travelled on 177°, and in 4 miles struck Winnecke Creek. From here the pointed hill bore 225°. We followed east along the creek. It soon formed into two channels, with sandy beds, one of which ran south of east and the other north-north-east. Farther on the branch we were on split up again. It was evident that the creek, as a defined watercourse, was nearing its end,

for it was spilling its banks all along, and ants' nests showed up all over the flooded flats. I have rarely, if ever, seen such an array of white ants' nests.

Our courses along the creek were north-east, north, north-west, and again north, and we camped at the Duck Pond Water-hole, which was just dry, as were other holes also. We sank a native well in the water-hole several feet deeper, but after expending much labour found the supply to be so small that it would hardly give water for our own needs, with none for the camels. Perhaps if made into a proper well, and timbered and sunk deeper, it might yield more water. On the 4th we travelled first north-east to where we crossed the Winnecke Creek on the way to Victoria river, and reached it in 6 miles from Duck Pond Water-hole. That water-hole was dry also, but some natives that we met on the creek piloted us to another, with a sheet of water 80 yards long, 15 and 20 yards wide, and 3 feet deep in the deepest part. This was, I think, the best holding hole we saw in Winnecke Creek, but it is not a permanent water.

From this hole we followed our outward pad right to Barrow Creek. In places the chain-track was almost obliterated by blowing sand. From water to water, where we had been piloted by black boys, I ran a prismatic compass traverse through the scrub, timing each run, and striking the through-bearing when plotted. In spite of every care the positions must be taken as approximate, for to get long-site shots is quite impossible, and there are no elevations to help one. However, all the waters set down on the map of my journey can now be found easily enough. The supplies in the wells could be greatly increased by sinking them a little deeper. My contract with the South Australian Government was to make trial wells, and the daily yield required was 1000 gallons. When that yield was obtained I had no cause to sink them deeper. They all yield well over the required quantity of excellent water.

We finished each well as we travelled back. In order to reduce the long stage between Cattle Swamp Well and Winnecke Creek we bored in a titree swamp 10 miles north-west of that well and obtained potable water at 9 feet 6 inches below the surface. It rose 2 feet 6 inches in the bore. We did not sink a well there, our provisions being at a low ebb. After we had replenished our food supplies at Barrow Creek we sank two wells (Baxter and Gettens wells) on the Hanson Creek, the positions of which may be seen on the map.

For the convenience of would-be travellers through that region I have set down the following particulars. Gettens Well is about 32 miles west-north-west of the Hanson Well on the Overland Telegraph Line. Baxter Well is 28 miles nearly due north of Gettens. These three are all on the Hanson Creek. The route then leaves the Hanson and in 28 miles on a bearing of 336½° is Circle Well; then on 306½° in 17 miles Fulge Well; in 21 miles on 298° Giant Well; on the same bearing in 6½ miles End Well; on 352° in 13 miles Hit or Miss Well; on 327° in 32 miles Green Swamp Well; on 290° in 22 miles Cattle Swamp Well. The distance covered by these permanent waters is 199 miles. From the latter well to Merrenu (or Duck Pond) Water-hole on Winnecke Creek is 52 miles and the bearing is 316°. Merrenu to Ross Gap is 22 miles, direction a little north of west and follow the creek. From Ross Gap on 319° one will strike the eastern portion of Hooker Creek, then follow up the creek north of west, and in 1½ miles past the big swamp is the Hooker Water-hole, the

distance being 36 miles. Then on 340° in 27 miles is Catfish Yard and Waterhole on Victoria river. The distance from Cattle Swamp Well is 129 miles. The waters are fairly safe for three months after the rainy season, but after that one can say nothing. From Hanson Well to Catfish Yard is 328 miles.

There is no immediate prospect of the completion of the North to South Railway, but in view of providing traffic to make the line payable the potentialities lying dormant for closer settlement in the large tracts of rich basalt soil of the Victoria river and adjoining districts should not be overlooked. If, instead of running the railway along the Overland Telegraph Line to Katherine it were taken off from it just north of Central Mount Stuart, and ran direct for Victoria river, and when nearing the river it followed along the eastern watershed, few, if any, serious engineering difficulties would be encountered right to the Katherine. The divergence would capture the trade of Victoria river and much of the Kimberley trade as well. It would also assist the development of all that rich country.

The object of the writer in compiling this account from very copious notes taken while the expedition was in progress is to place on record accurate information regarding a portion of the interior of Australia of which less is known probably than of any other part of the continent. Only by following the daily record of the journeys, I think, can anything like a correct idea of the country passed through be obtained, unless the route be travelled over. No generalized account could convey a correct impression of such unusual conditions. That the country is able to support a sparse native population we know, but to what useful purpose it can be turned for the benefit of stock-raisers, beyond affording facilities for shifting stock from place to place, is not yet apparent. The most unusual and most remarkable feature about it is, as has been pointed out, the existence of immense stores of water obtainable over very large areas from quite close to the surface. As the water is perfectly fresh and suitable for irrigation, it should be possible to turn the land to some useful account as is done in other arid countries. In addition to those hollows in which we obtained water so easily I am quite certain that there are a great many others that would yield equally copious supplies. Similar conditions obtain over a stretch of 150 miles, as proved by our line of wells. The width of the water-bearing area is unknown.

To my knowledge no surface indications of either coal or oil have been seen on the route we followed, but the shale and sandstone formation between Cattle Swamp Well and Victoria river is worth testing, and the Duck Pond on Winnecke Creek would be a good site to bore at. What lies below that great sand plain and sandhill area crossed by us is unknown. From End Well to north of Cattle Swamp Well no outcrops of consolidated rock were noted. A bore at a spot like Green Swamp Well put down to bedrock might afford valuable information. A vast depression apparently existed there in former times, which seems now to be nearly filled, but we know nothing of what lies below the surface sand.

Adieu Ridge and Scott Hills were the two most northerly points at which veins likely to carry valuable minerals were seen. At the latter quartz veins were much in evidence, but there was nothing of value in them. From these

hills right to Victoria river along our route no outcrops of metamorphic or eruptive rocks were seen.

As regards the natives: they were never hostile, but of course ours would have been a strong party for them to tackle. We were well armed and they knew it. We gave them no cause whatever to be hostile, and any food we could spare we gave them. We tried to make them feel safe with us provided they left us alone, and in this we succeeded with all but those who lived far out in the sand-hill country. They were very suspicious and would hide themselves while we were travelling or when in camp. We owe much of our success to our own boys, and to natives who piloted us to waters in the country beyond where our boys had been. If we could have obtained the help of the wild natives no doubt they could have shown us many more waters, some of which must be surface waters, otherwise parrots, pigeons, doves, and cattle could not exist there.

THE OLD ENGLISH MILE

COLONEL SIR CHARLES CLOSE, K.B.E., C.B., C.M.G., SC.D. F.R.S.

IN studying the old maps of England, or of the shires, one very soon finds that the mile has not the same value that it has at present. The existing statute mile, of 1760 yards, appears to have come into legal existence by the statute of 35 Elizabeth (1593), which defines the mile as 8 furlongs, or 320 poles, or 1760 yards. I am informed by the Deputy Warden of the Standards that, so far as the yard is concerned, there appears to be no reason to think that any material change has taken place for several centuries, and that it is certain that no such change has occurred since about 1500 A.D.; authentic standards of that period still exist. We may, in fact, look upon the yard as relatively stable and subject to little change.

It is very different with the mile. Let us first see what is the length of the mile on our earliest detailed map of Great Britain, that remarkable map which is in the Bodleian Library at Oxford. The date of this map is about 1300 A.D. The scale is about 17½ miles to the inch, but, fortunately, for this purpose we have no need to depend upon the scale, because the distances between the towns are marked in miles. Sometimes, but not always, these distances are rounded off. Here is a list of eight such distances, compared with the modern distance by road measured on the ¼-inch Ordnance Map :

	Distance on old map.	*Modern distance.*	*Old mile in terms of statute mile.*
Coventry–Leicester	XVI	23	1·4
North'ton–Harbro'	XII	17	1·42
Leicester–Harbro'	XII	14	1·17
Coventry–Daventry	XVI	19	1·19
Malmesbury–Bristol	XX	24	1·19
Reading–Oxford	XX	28	1·40
Oxford–Malmesbury	XXX	40	1·35
Winchester–Salisbury	XX	21	1·05

The mean of these measurements would seem to show that the old mile was, in the year 1300, about 1·25 of the modern mile, or, in other words, that the old mile was a mile of 10 furlongs. But it may be objected that we do not in all cases know what roads were followed six hundred years ago. That is, of course, true. But it is also true that the route followed in the Middle Ages must in every case be longer than the direct distance, and if we compare the distances given on the Bodleian map with the direct distances, we shall in every case obtain a smaller value for the old mile than is correct. I have measured twelve other distances and have compared these direct distances with the numbers given on the Bodleian map. The mean of these comes out as 1·30. So I think that we may say that the old mile used for this map was not less than 10 furlongs.

The above paragraphs may serve to show the kind of variations to be expected in deducing the old mile from the Bodleian Map. When I wrote them I had not known of an important paper by Mr. Wm. Flinders Petrie, now Sir Flinders Petrie. This paper is entitled "The Old English Mile," and appears in vol. 12 of the *Proceedings* of the Royal Society of Edinburgh, Session 1883–4, p. 254. He therein points out that the Bodleian Map is capable of furnishing valuable information on the subject. Sir Flinders studied the original map itself, and says: "It seemed very evident that all the distances in the south and east of England had been rewritten by some hand well accustomed to mediaeval script; . . . This rewriting deserves careful study in considering the map; and as it was apparently done before the sixteenth century, . . . it is some evidence as to the great age of the map. . . . What is now much needed is a critical examination of this map. . . . This work needs a good palaeographer; but for the question of the miles, which is what we have at present to consider, such care is not required; for if a few doubtful distances are omitted, it will not perceptibly affect our results." He omits from discussion the distances in Wales and Cheshire, " which show a different mile," and finds that there are 130 distances available for examination, and that the mean value of the old mile is 1·265 of the statute mile, that is, 10·12 furlongs. He also points out that the old French mile was equal to 1·21 statute miles (2130 yards) of 10 furlongs, with 10 chains to the furlong.

After the Bodleian Map we have no source of information about the length of the mile until we come to the year 1544. In that year there was published "A CRONYCLE OF YERES from the begynnyng of the worlde wherein ye shall fynde the names of all the kynges of Englande. . . . And also the wayes leadynge to the most notable places: and the dystaunce betwyxte the same. Anno 1544 . . . Imprynted at LONDON in Fletestrete, at the signe of the George by Wyllyam Myddylton." The late Sir George Fordham reprinted these old road tables in 1927.*

Nine road tables are given: Walsyngham to London; Berwycke to Yorke and so to London; Carnaruan to Chestre and so to London; Cokermouth to Lancastre and so to London; Yermouth to Cholchestre, and so to London; Douer to London; Saint Buryen in Cornewell to London; Brystowe to London;

*'The Earliest Tables of the Highways of England and Wales, 1541–1561,' by Sir Herbert George Fordham. Reprinted by the Oxford University Press from the *Transactions* of the Bibliographical Society, 1927.

saint Dauids to London. In each case many intermediate distances are given, so that it is easy to follow the route taken.

I have measured the distances by road on a modern map, leaving out the route from Carnarvon to Chester and the western part of the Saint Buryen route, and have compared the eight long distances as given by Myddylton with the modern distances, by road, in statute miles, with the following results: The Old Mile in terms of the Statute Mile works out as 1·41, 1·37, 1·24, 1·24, 1·22, 1·23, 1·36, 1·33. The mean is 1·30.

After the Bodleian Map there is a gap of more than two hundred years during which no maps of this country have survived, and we can pass to the year 1546, in which the first printed map of the British Isles was issued. This is attributed to George Lily; it has a scale of miles. It was suggested by Mr. Heawood that in some cases these old maps might have become distorted by unequal expansion, east and west, and north and south. I have made twenty measurements of distances by Lily's scale, running generally in a north-south direction, and find that Lily's mile in this direction is 0·94 of a statute mile. In the other direction, that is east-west, Lily's mile came out, as the mean of twenty measurements, 0·91 of a statute mile. It would therefore appear that Lily's mile was about 0·92 of a statute mile, or about 7·4 furlongs.

Lily's map has the latitudes and longitudes marked along the margins. The mean length of a degree of latitude in Lily's miles is 66·2, or 61·2 statute miles. It should be about 69·2 statute miles. In fact, if the latitude divisions are correct the delineation of this country is wrong and *vice versa*. But we need not spend any more time on this map; the miles of Lily would appear to be Italian miles.

Mercator's "Angliae Scotiae et Hiberniae Nova Descriptio" was printed in 1564. This map shows a scale of English miles. I have measured seventeen direct distances on this map, and have compared these distances with those derived from a modern map. In two cases out of the seventeen the old mile came out smaller—0·96 and 0·98—but, including these, the average length of the old mile came out as 1·184 of the modern mile, that is 2084 yards, or 9·47 furlongs.

And now we come to the first detailed surveys of this country, the County Maps of Saxton. I take as an example the Map of Southamtonia, or Hampshire, printed for Saxton in 1575. I have measured twelve direct distances on Saxton's map, and have compared these distances with the direct distances taken from the Ordnance Survey ¼-inch map. In every instance the old mile comes out longer than the modern mile; the smallest ratio being 1·16 and the largest 1·27. Of course it is not possible to make very exact measurements for the towns are only conventionally drawn. But there cannot be much wrong with the mean, which shows that the old mile was about 1·216 of the modern mile; that is 2140 yards, or 9·73 furlongs.

Mr. Heawood has taken twelve measurements on Saxton's map of Norfolk: six in a north-south direction gave a mile of 11·10 furlongs; and six in an east-west direction gave a mile of 10·91 furlongs. The general mean being 11·00. He similarly measured Saxton's maps of Northants, etc., twelve measurements gave a mean of 11·23 furlongs. Shropshire gave a mean of 11·03 from sixteen

measurements. In these three maps the smallest mile came out as 8·75 and the largest 12·47.

Including the measurements of Hampshire, mentioned above, the mean for the four counties was 10·75 furlongs to the mile. A miscellaneous series gave 10·42. Petrie, in the article above quoted, says that he examined Saxton's county maps and from thirty (? twenty-eight) totals deduced a mean result of 1·310 statute miles $\pm$0·016. This is equivalent to 10·48 furlongs. It is not stated how many measurements were made on each map.

Mr. Heawood has also taken twenty-two measurements of Saxton's Large Map of England and Wales, 1583, and finds that the mile was 10·48 furlongs long.

From Norden's County Map, 1593–5, he obtains a mile of 10·17 furlongs; from Symonson's Large Map of Kent, 1596, a mile of 9·82 furlongs; and from Speed's County Maps, 1608–11, a mile of 10·33 furlongs.

The Deputy Warden of the Standards has kindly pointed out to me that there is a discussion of The Old British Mile in a book by the late Frederic Seebohm, entitled 'Customary Acres and their Historical Importance.' Seebohm quotes from 'Harrison's Description of Britain,' prefixed to the 1577 edition of Holinshed's *Chronicle*, the following remark: "As for the old British mile that includeth 1500 paces English, it shall not greatly need to make any discourse of it, and so much the less sith it is yet in use and not forgotten among the Welsh men, as Leland has noted in his Commentaries of Britain." Seebohm gives the pace as being the double step of either 58 or 59 inches; the old British mile would then be 11 furlongs or 11·2 furlongs. If the pace were reckoned as a double step of 60 inches, the old British mile would be nearly 11·4 furlongs. This would be the Welsh mile.

Both Petrie and Seebohm refer to Ogilby, who published his 'Britannia' in 1675. In this he gives "the horizontal distance," as the crow flies; "the vulgar computation," that is the distance in the old miles; and the "dimensuration," that is the statute miles measured by perambulator. In Seebohm's view the miles in the neighbourhood of London were smaller than those at a distance; this may, perhaps, be a little doubtful. Seebohm takes the total for the direct routes out of London in all directions for the whole of England and Wales, and a certain number of other routes, and finds that 3507 miles by "vulgar computation" are equal to 4536 statute miles, *i.e.* the old mile was equal to 1·29 of the statute mile. The mean of two other groups came out as 1·31. So far as his figures go therefore the old mile in 1675 was perhaps about 1·30 statute miles or 10·4 furlongs; though he gives some reasons for preferring a value that works out at 1·35 statute miles.

Sir Flinders Petrie, in the paper mentioned above, discussed 154 distances given by Ogilby, of which 8 are rejected as belonging to the north-west mile, and 12 as belonging to the Welsh mile. For the mean of the remaining 134 lengths he finds that the old mile was 1·307 of the statute mile, or 10·45 furlongs.

Seebohm* gives a list of distances, omitting Lily and Mercator, noted by Leland, from Worcester to places within 20 miles. Leland's mile works out as 10·63 furlongs or 1·33 statute miles.

*'Customary Acres and their Historical Importance,' by F. Seebohm. Longmans, Green & Co., London, 1914.

To sum up, the following is a list of the values of the old English mile, derived from a study of old English maps and itineraries. The mean mile of the ten ancient authorities quoted is 10·36 furlongs or 1·30 statute miles.

Date A.D.	*Map or Itinerary.*	*Value of O.E. Mile.* *Statute miles.*	*Furlongs.*	*Remarks.*
1300	Bodleian	1·265	10·12	Petrie's value from 130 measurements.
1544	Myddylton	1·30	10·4	From the eight long distances given.
1546	Lily's	0·92	7·4	Probably an Italian mile.
1564	Mercator's	1·184	9·47	
1574–79	Saxton's County Maps	1·310	10·48	Petrie's measurements.
,,	,,	1·344	10·75	Four counties; the mean of 52 measurements; chiefly Heawood.
,,	,,	1·303	10·42	Mean of 21 miscellaneous measurements; Heawood.
1583	Saxton's Large Map of England and Wales	1·310	10·48	Heawood; from 22 measurements.
		[1·255	10·04]	[Petrie from measurements on "The Quartermaster's Map."]
1593–95	Norden's County Maps	1·271	10·17	Heawood.
1596	Symonson's Large Map of Kent	1·228	9·82	Heawood.
1608–11	Speed's County Maps	1·291	10·33	Heawood.
		1·300	10·40	Petrie.
1675	Ogilby	1·30 or [1·35]	10·40	Seebohm; from lengths over the whole of England.
,,	,,	1·307	10·46	Petrie; from the mean of 134 lengths.
1695	Gibson's maps	1·290	10·32	Petrie.

Note.—Between the years 1574 and 1695 there seems to have been no progressive alteration of the old English mile, which remained at an average of about 10·3 furlongs. Petrie also mentions "The Quartermaster's Map" of 1644; but the late Sir George Fordham has shown that this was copied from Saxton's Large Map, mentioned above.

It is clear that the old English mile was very different from the statute mile; but, as might be expected, measurements on different maps, and even on the same map, give very varying results. The Bodleian mile was about 10·12 furlongs long, and Petrie thinks that the original old mile was identical with the old French mile, based on the mediaeval foot of 13·22 inches. The old measurement had the relation 6 feet=1 fathom; 10 fathoms=1 chain; 10 chains=1 furlong; 10 furlongs=1 mile. The Bodleian mile seems almost certainly to have been descended from a mile of 10 furlongs.

In sixteenth and seventeenth century maps are to be found, occasionally, long miles, mean miles, and short miles. But with the exception of those taken from Saxton's large map, which are long miles, the miles given in the foregoing tables have no qualification and may be taken as the customary miles.

For a considerable period, at least from 1544 to 1695, in spite of the existence of the statute mile of 1593, the customary mile in England was about 1·30 statute miles.

GEODESY AND GEOPHYSICS AT STOCKHOLM

THE fourth General Assembly of the International Union of Geodesy and Geophysics was held at Stockholm from August 15 to 23, the Section of Geodesy, according to their excellent custom, getting to work three or four days in advance, before the demands of general meetings, hospitality, and excursions draw seriously upon the time available for the real business of the Section. The Assembly was amply lodged in the Parliament House adjacent to the Royal Palace, the large Section of Geodesy occupying one of the two principal chambers, with vast corridors and suites of offices and committee rooms at its disposal, the smaller Sections equally well supplied according to their needs. In this sumptuous building the Stockholm local committee had established an organization of which it is hard to speak too highly, and several of their devices must serve as models for the future, in particular the list of members with portraits of all who had responded to their request for a photograph. A large staff of untiringly helpful polyglot ladies wrestled with the minor difficulties and perplexities of the delegates to general admiration.

The Assembly met under the shadow of an approaching revision of its statutes to conform with the reorganization of the International Research Council; and the old tendency to defer any awkward question, such as the duration of the Presidency, to the next General Assembly was thereby strengthened. This reluctance to make any change in organization if it can possibly be postponed by specious argument or administrative device is a weakness of such assemblies which wastes time and tends to annoyance rather disproportionate to the merits of the case. For the wonder is that an assembly with no common language and widely different habits of public business should ever come to a conclusion. A cynic at such meetings would maintain that if a majority had any real idea of what was under discussion, they never would. But in practice there is a strong tendency to follow a lead, whenever it comes to a question of voting in the elaborate manner provided for the settlement of any administrative affairs. Voting power is according to a scale based on population, with a maximum of five votes per country, all given by the representative of that country authorized to deliver the vote. Indo-China, counting five, may be trusted to follow the lead of France; the British Dominions have not so far shown that disposition to vote against Great Britain which the late Earl of Balfour thought was so educative a feature of the League of Nations. There are groups of European countries which vote pretty regularly together on opposite sides, not altogether content that the weight of their votes should bear so little relation to their scientific standing. For this reason there is a movement towards the principle—One country, one vote; and the British delegation were agreed to support it; but that was one of the questions which got shelved until the next General Assembly.

A firm stand against delay did however produce one very necessary reform. It was resolved that in future a President of the Union should hold office for only one term, and should not be eligible for immediate re-election. The number of men qualified by nature and art to adorn the presidential chair is admittedly small; but opinion had gained ground that it was better to run the risk of an occasional bad President than to re-elect continually the same man,

however marvellously endowed with all the Presidential graces. By a rather narrow vote on the last day it was agreed that the question be no longer deferred; and then, with only one contrary vote, and that perhaps from failure in a position of alphabetical priority to foresee a sudden change of tactics, it was all but unanimously resolved that there should be a change of Presidency at every General Assembly.

During his twelve years' tenure of office, covering the whole life of the Union, Monsieur Lallemand has displayed all the qualities which make the perfect President: felicity of language in evoking the memories and the sentiments proper to the place of meeting; quickness to see a point, however badly presented, and skill to evade it when he judged expedient. It was unfortunate that his rigid adherence to the strict letter of a law made in other conditions involved him at the beginning of the Stockholm meeting in a stiff fight on a rule of procedure which seemed to others hardly worth maintaining when the principle underlying it had been abandoned four years before. Germany has not in that time found her principal scientific academy willing to adhere to the International Research Council, and has debarred herself thereby from membership of the Union of Geodesy and Geophysics. In that case it was by the statutes open to the President to invite German scientific men to attend, and he was willing to do so, on condition that they asked for the invitation. They, on the other hand, were prepared to start for Stockholm at a moment's notice, but refused to ask. Against the unanimous pressure of all other countries the President held out stoutly for a long time, and those who condemned his attitude perhaps forgot that a Frenchman sees nothing strange in the custom that every candidate for the Paris Academies makes a round of visits to the Academicians. After a vigorous resistance he gave way, and in a few hours Drs. Kohlschütter and Hecker appeared in the Section of Geodesy. It is desirable to put these facts on record for comparison with the analogous but in detail very different difficulty that arose before the meeting of the Geographical Union two years ago.

The quality of General Perrier as Secretary of the Geodetic Section is well displayed in his triennial report, which in its first section shows how much may be accomplished in administration and publication by the judicious expenditure of about £1,500 per year, and makes a good case for increased resources, which will be found if the proposed increase of the unit contribution is ratified. It was only the mistake of fixing the contributions originally in francs without specifying that they should be gold francs that has starved the whole Union since the fall in the French exchange. The Secretary's report welcomes the adherence of seven new states; reproves some of the older members for doing nothing but pay their subscriptions; regrets that nine have not yet formed National Committees for Geodesy and Geophysics, and that eight have not nominated representatives on the Permanent Commission; for experience has shown that it is better for the secretariat to address them rather than the national committees when it desires a prompt and clear reply.

The scientific section of the report deals first with the progress of the Commission for a meridian arc from the Arctic Ocean to the Mediterranean, continued through Africa: that is for the completion of the arcs known by the names of Struve and Gill, and their junction by a circuit of the Eastern

Mediterranean lands. The combined efforts of Greece, Yugoslavia, Romania, and Czechoslovakia show the advantages which may come from the enterprise and perhaps the rivalry engendered by the meetings of an International Union, and something more might have been said here, as it will doubtless be said in the full report of the Commission, on the contributions made by Italy and by Egypt. "Dans le nord," says General Perrier, "l'état de la question est stationnaire," which is surely unjust to the Baltic Commission. They may have a certain preference for doing their own job without too much account of the machinery of the Union; but we think that stationary is the last word an impartial observer would choose to describe the activities of which Professor Bonsdorff is the leading spirit, and that the circuit of the Baltic which will replace the very weak connection with Scandinavia made by Struve is one of the soundest enterprises in European geodesy. In Africa the Survey of Egypt have carried their triangulation to the Sudan frontier and are prepared to go eastwards to that of Palestine; and as a result of Brigadier Winterbotham's recent journey in Africa a British party will soon take the field to make the connection southward with the Uganda arc measured some twenty years ago by Brigadier Jack, and thence southwards to join Gill's triangulation south of Tanganyika.

General Perrier is resolved that if there is some reluctance to adopt the celebrated International Ellipsoid or Madrid Figure of 1924 it shall not arise from want of the necessary tools. He has published and widely distributed very precise and extensive geodetic tables in both sexagesimal and centesimal systems, and tables for the calculation of geodetic coordinates in both systems (*Bulletin géodesique*, 1926, p. 188, and 1927, p. 135). Also a bibliography of current geodesy is in hand and will be printed when funds permit, a memoir by Mr. W. D. Lambert of the U.S.C.G.S. on the reduction of observed values of gravity to sea-level will be published immediately; the *Bulletin* has already given many documents involved in the threatened international standardization of geodetic work, and two volumes of reports on bases and on triangulations await funds for printing. The labours of the assembly at Praha in 1927 have been published in many numbers of the *Bulletin* and in three volumes of *Travaux*. The Section of Geodesy may well be content that General Perrier has been willing to undertake for another term the arduous duties in which he is so conspicuously successful.

The detailed labours of the Section begin with the presentation of the national reports, from which we may extract only a few picturesque facts. Canada now transports and supplies its field parties by air, and can move an observing party or several signal parties in an afternoon instead of a month. Denmark will be the next power to devote a submarine to the measurement of gravity at sea. President Hoover has tripled the appropriation for geodesy in the United States, where an adjustment of the level net shows that mean sea levels at many stations do not lie on the same equipotential surface, northern stations being on the average three decimetres higher than the southern, and Pacific stations six or seven higher than Atlantic. Finland has reobserved the triangulation of Maupertuis, made seventy-one new gravity stations in the last three years, and striking economies in the cost of astronomical points. France has to report "une veritable efflorescence des jonctions" with Belgium, with

Italy, with M. Paul Helbronner's meridian of the Alps, with Spain in Morocco, and with the British triangulation in Palestine. Egypt has made gravity stations in the Delta and finds that the centre of gravity of the whole deposited material lies out at sea north of the coast. Indo-China has measured seven new bases and formed a section of astronomy and radiotelegraphy. India has found a wave-length in the geoid of 800 miles having no relation to the superficial topography or geology, and gives results of great interest on the longitude term in the figure of the earth. Japan has studied new methods of comparing standards with the wave-length of light. Norway has made three level connections with Sweden, and will make a fourth this year. Switzerland has been observing new primary longitudes and readjusting its longitude net. And nearly all countries have been active in making Laplace points for controlling the azimuths of their triangulations. Great Britain's contribution to the geodesy of Europe was three gravity stations, and any one who thinks that this must have made a mighty poor appearance in the Section of Geodesy will think no more than the truth.

Of the many important communications made in the various Commissions we can mention only a few. Mr. A. E. Young read a paper which seems to be of the first importance on a general conformal projection, including in one general theory the recent development by Courtier and Laborde, following on J. I. Craig's developments of Liouville's theorem which was really due to Cayley. The formulæ are complete and not developments in series; but since they are all expressed in hyperbolic functions, they will give some trouble to those who have been reared in Sir Charles Close's celebrated principle that the map-maker should draw the line at the root of minus one. Dr. Vening Meinesz presented a report on his third submarine voyage in the Netherlands Indies, where he recently spent five months at sea and made 234 stations. We look forward to hearing more about this remarkable work at the first afternoon meeting of our session.

It was a great disappointment that Father Lejay had small opportunity to do justice to his account of the new gravity pendulums which he has devised, with a small rod of quartz about 5 cm. long mounted at the upper end of a spring of *elinvar* whose strength is just sufficient to control the oscillation of the rod about a vertical position, with a period of about a second. The effect of a variation of gravity is about twenty-five times as great on this as upon a free pendulum. The vibration is recorded by obscuration of a photo-electric cell; a complete swing takes only a few minutes, and a complete determination of g is made in a quarter of an hour, "calculs compris." Unhappily a set of five pendulums had been broken on the journey by a railway porter at Cologne, and we were able to admire only the general disposition of the apparatus and some preliminary results of high promise. If the elasticity of the *elinvar* spring does really remain constant this will revolutionize gravity survey.

In his report on Geodetic Astronomy Mr. Jolly referred to the proposal for a large new determination of fundamental longitudes proposed by General Ferrié, remarking that the first operations had never been studied critically. The use of the astrolabe in field astronomy is not yet general, nor is it likely to be if, as the report avers, it gives errors fifty per cent. greater than do other instruments for determining local time. The statement must surely need

qualification. The Norwegians, faced with the problem of observing Laplace points in high latitudes, had made several suggestions which needed study. In receipt of W/T signals for longitude semi-automatic methods give better results than complete automatic registration.

Such are a few of the facts and the ideas laid before the Section of Geodesy in the reports of nations and of special commissions. As one sat in the Section a steady stream of booklets with occasional volumes was directed upon the delegates from the Bureau; the collection of the delegate who writes weighed some thirteen kilogrammes. One notes an approach to uniformity of size and a very general improvement in printing, which will add much to the appearance of the *Travaux* in which they are eventually bound together.

In the anticipation that before the end of the meeting it would be necessary to choose a new President of the Section, one listened with a new interest to each speaker and gave marks, too often bad ones, for style of delivery. But whether it was that, or the invincible repugnance of an international scientific body to any change of personnel, the declared intention of the old President faded away and he was unanimously re-elected for a further term. One change was however made in the Executive Committee, Professor Bonsdorff of Helsingfors replacing Dr. Heuvelink, as the result of a ballot which originated in some doubt of who was due to retire.

It remains to speak of the external events: the reception at the Royal Palace by the Crown Prince and Princess; the sumptuous hospitality of the City in all the complicated splendour of its celebrated City Hall; the visits to Upsala and to Saltsjöbaden now crowned by the new astrophysical observatory with which a munificent patron has endowed the University, to the Geodetic Section of the General Staff and the Geochronological Institute of Baron de Geer; and the farewell banquet given by the local committee at Hasselbacken. Stockholm gives a magnificent setting to such an assembly, and the generous cordial hospitality of its King and his people will be held in grateful remembrance.

CONFORMAL MAP PROJECTIONS

LA NOUVELLE PROJECTION DU SERVICE GEOGRAPHIQUE DE MADAGASCAR. Par LE CHEF D'ESCADRON LABORDE de l'artillerie coloniale. *Cahiers du Service géographique de Madagascar, No.* 1. *Tananarive, Avril* 1928. 70 *pages lithographed.* [*Presented by the Author to the Library of the Society.*]

THIS appears to be the first of a series of technical pamphlets to be issued by the *Service géographique de Madagascar*, of which Commandant Laborde is the chief, and its object is twofold, first to give a general résumé of the theory of conformal projections with a description of some theorems in that subject which the author has discovered and claims or suggests to be new, and then to describe the actual variant selected by him for the reduction of the triangulation and for the mapping of the island of Madagascar, with an example of the working of the various calculations of the rectangular coordinates and the corrections to bearings and distances. The author is to be congratulated on his clear exposition of the problem and the enterprise shown in his research, but he has apparently not made himself fully acquainted with the work done by others, for, with the exception of Gauss, one of whose theorems in his *Disquisitiones Generales circa Superficies Curvas* (1828) forms the basis of the author's own researches, he mentions only his compatriots Tissot, Hatt, Courtier, and Roussilhe. As a matter of fact the whole problem of conformal mapping of the spheroid was solved by Lagrange in 1774, though his results were left in a form not easily interpreted; but since the time of Gauss very useful simplifications have been made by Tchebychev in Russia, Schreiber and Jordan in Germany, Pizzetti in Italy, and J. I. Craig in Egypt. In 1860 Tissot first published his method of obtaining by expansion in series the best conformal projection to suit a country of any shape, which method he further developed in his *Mémoire sur le Représentation des Surfaces* (1881); and although it has been shown subsequently that the ordinary projections so obtained are identical with or differ so little from those already known that it is not worth while using Tissot's method, yet that method, perhaps naturally, appeals so strongly to the French geodesists and cartographers that they still seem to prefer it to the other previously discovered methods referred to.

Commandant Laborde bases his investigations on two equations, Nos. (6) and (7), p. 17 (which he has deduced from the classic equation of Gauss for the total curvature of a surface), for the difference between the total curvatures of the original surface and its conformal representation, in terms of the scale and its partial differential coefficients with respect to the orthogonal curvilinear coordinates of the original surface. The details of these two equations are not given, and I am inclined to think some error has been made in deducing them and that the middle terms in brackets on the left-hand side, involving the curvatures of the coordinate lines, should not appear. However, this error, if it be an error, does not affect the subsequent deductions, for the plane map being taken afterwards as the original surface these curvatures are necessarily zero. Commandant Laborde is then led to the following differential equation for the conformal representation of the spheroid on a plane map, eq. 10, p. 20:

$$(1+Z)\left(\frac{\delta^2 Z}{\delta x^2}+\frac{\delta^2 Z}{\delta y^2}\right)-\left[\left(\frac{\delta Z}{\delta x}\right)^2+\left(\frac{\delta Z}{\delta y}\right)^2\right]=\frac{1}{\varrho\varrho'}$$

where Z is the scale error of the map and $\varrho\varrho'$ the principal radii of curvature of the spheroid. This result is however not really new, for Liouville has pointed

out (see *Liou. Jour.*, tome 12) that if the element of surface can be put in the form $ds^2=\lambda\{(d\alpha)^2+(d\beta)^2\}$ then the total curvature is given by

$$-\frac{1}{2\lambda}\left\{\frac{\delta^2\log\lambda}{\delta\alpha^2}+\frac{\delta^2\log\lambda}{\delta\beta^2}\right\}$$ (Published first by Gauss in 1822)

Putting $\lambda\equiv\left(\frac{1}{1+Z}\right)^2$, $\alpha\equiv x$ and $\beta\equiv y$ we see this readily reduces to the form above.

Commandant Laborde then shows how the above equation can be solved in series, and restricting himself to the principal term, Z_2, involving the second powers of the coordinates only, or, $\frac{\delta^2 Z_2}{\delta x^2}+\frac{\delta^2 Z_2}{\delta y^2}=\frac{1}{\varrho_0\varrho_0'}$, he is led to the result already found by Tissot, viz. $Z=\frac{1}{4\varrho_0\varrho_0'}[(1-n)x^2+(1+n)y^2]+\ldots$ where n is a constant.

Now Tissot's criterion of the best map is that in which the maximum scale error is as small as possible, and as the above expression for the scale error shows that the line of equal error is an ellipse, it follows that the constant n should be taken equal to $(p^2-1)/(p^2+1)$, where p is the ratio of the longer axis of the ellipse to the shorter. As the error for a radius of the ellipse inclined at 45° to the axis is independent of p, being simply $r^2/4\varrho_0\varrho_0'$, Tissot recommends trying various ellipses which surround the tract to be mapped until that one is found which makes the radius r at 45° as small as possible. The inclination of the axes of this ellipse to the meridian is then noted and also the ratio of its axes. The magnitude of the maximum error at the boundary is reduced to one-half by applying a general scale constant $A=1-a$, where $a=\frac{1}{2}r^2/\varrho_0\varrho_0'$, which makes a negative scale error at the centre equal to the positive scale error at the boundary. If the map has equal extent in both directions we take $p=1$ and $n=0$, leading to the Stereographic Projection. If it has indefinite extent in the x direction we take $p=\infty$ and $n=1$, leading to the Gauss Conformal Projection; and if it has indefinite extent in the y direction we take $p=0$ and $n=-1$, leading to the Mercator Projection.

It should be noted that these results of Tissot's are really inherent in Lagrange's Projection; for if the scale in that projection be expanded in terms of the coordinates, taken from the point where $dm/dx=0$, we get, using Germain's notation except that x is changed for y so that x is the usual NS coordinate,

$$m=1+\frac{1}{4N^2}\left\{\frac{1+\sin^2 z_0+2e^2\sin^4 z_0-4c^2}{\sin^2 z_0}x^2+\frac{4c^2-1+\sin^2 z_0}{\sin^2 z_0}\cdot y^2\right\}+\ldots$$

N is here the grand normal, and if we substitute for N^2 the product $\varrho_0\varrho_0'$ above we have $N^2=\varrho_0\varrho_0'(1+e^2\sin^2 z_0)$. This is obviously Tissot's result in a different form and we easily arrive at the equation

$$4c^2=(1+e^2\sin^2 z_0)\left\{1+\frac{p^2-1}{p^2+1}\sin^2 z_0\right\}$$

which, except for the term in e^2, is identically the result arrived at by Tchebychev in 1853 (see Germain, pp. 75–79 for a copy of the memoir). At the end of this memoir, which seems to have escaped notice by subsequent investigators, Tchebychev promises to publish more detailed results, but I cannot discover that this was ever done. Lagrange's Projection in fact completely solves the problem of mapping the spheroid conformally and includes the Stereographic for which we make the square of the exponent $4c^2=1+e^2\sin^4 z_0$, the Conical Orthomorphic for which we make $4c^2=\cos^2 z_0$, and the Mercator for which

we make $4c^2=0$ and $z_0=90°$. The only restriction Lagrange imposed was that the projected meridians and parallels should be true circles, but this does not affect terms of the second order in the expansion of the scale error. The restriction has this effect however that if we make $4c^2=1+\sin^2 z_0+2e^2\sin^4 z_0$ our coordinates do not agree with those of the Gauss Conformal or Transverse Mercator beyond terms of the second order. For a map of large extent in latitude therefore it is better to use Gauss's formulae, as they are simpler and preserve an absolutely uniform scale in the x coordinate. Lagrange and Tchebychev did not consider the case where the axis of the country to be mapped is inclined at an angle to the meridian, but the procedure to follow in that case is fairly obvious. On such a skew map the actual meridians and parallels will not necessarily project as true circles, and if spheroidal terms are to be taken into account a conformal projection on to the Gaussian sphere of best fit should first be made as described in Jordan, Vol. III. Lagrange's formulae with exponent equal to $1+e^2\sin^4 z_0$ completely solve the Stereographic Projection for the spheroid and might have been used by M. Roussilhe for the new cadastral map of France instead of the rather roundabout expansion method recently adopted by him.

With regard to the determination of the two constants a and n in the expression for the scale error

$$Z=-a+[(1-n)x^2+(1+n)y^2]/4R^2$$

there is another criterion besides Tissot's of making the maximum scale error as small as possible, namely, that of Airy of making the square of the scale error integrated over the map as small as possible, which is equivalent to making the average scale error as small as possible. Airy's criterion appears to me on the whole preferable to Tissot's, as among other advantages it makes the total area of the map true and leads to simpler formulae (see *Some Investigations in the Theory of Map Projections*, R.G.S. Technical Series No. 1, 1920). When this method is applied to a rectangular map of sides 2X and 2Y where $X/Y=p$ I find

$$a=\frac{Y^2p^2}{6R^2}\cdot\frac{(p^2+1)}{(p^4+1)};\quad n=\frac{p^4-1}{p^4+1};\quad \mu^2=\text{square of average scale error}=\frac{Y^4p^4}{45R^2(p^4+1)}$$

If we make p indefinitely great it will be found that these values agree with those for the Gauss Conformal Projection, as given on p. 35 of my pamphlet, except that μ^2 in the latter is twice as great, because in that pamphlet I count the square of the scale error in the orthomorphic projections twice over to compare them with the scale errors at right angles in the other projections. The above expressions show very clearly that it is hardly worth while giving to n any other values than zero or unity, *i.e.* $p=1$ or ∞; for even if $p=2$ and we assign the proper value to n we only reduce the value of μ^2 by $\frac{1}{16}$, *i.e.* of μ by about 3 per cent.

Returning to Commandant Laborde's memoir: he finds that the axis of Madagascar is inclined at about 21 grades to the meridian and that its longer dimension is to its shorter as 16 : 6, or $p=2\frac{2}{3}$. He accordingly adopts a skew cylindrical projection inclined at the above angle and takes $n=1$, instead of assigning to n its proper value of $(p^2-1)/(p^2+1)=0{\cdot}75$ on Tissot's criterion. Undoubtedly it was not worth while complicating the formulae by so doing, for even if Airy's criterion had been adopted the taking of n equal to 0·98 instead of unity would only have reduced the average scale error by about 1 per cent. A general scale constant of $-1/2000$ is applied which practically reduces the maximum boundary error by one-half. A conformal representation of the spheroid on the Gaussian sphere of best fit is then made about the standard latitude of 21 grades south, after which the isometric coordinates are calculated and from them the final coordinates of the projection in series up to terms of the

third order. A very thorough examination is made of the formulae for calculating the curvature of the projected geodesic, the difference between its length on map and spheroid and between length of geodesic and its chord on the map, also for the angular deviation between tangent to geodesic and its chord. Most of these formulae had already been worked out by Gauss, Schreiber, and Jordan, but Commandant Laborde's résumé is the clearest and most complete I have seen of them.

With regard to the adoption of a skew projection for Madagascar, I hazarded the opinion in my pamphlet (see p. 33 and p. 50) that it was practically never worth while to do so, unless perhaps the skew axis were inclined at 45°; and in spite of Commandant Laborde's arguments I still adhere to my opinion. For I consider that where it is necessary to know or estimate the errors of a map, simplicity of the expressions for the errors is of much more importance than their magnitude. And of all the projections that which has the simplest expressions for its errors is the Stereographic. It is the only one in which Tissot's and Airy's criterions lead to the same result, so that both maximum and average scale errors are as small as possible; its total area is true; and every circle on the spheroid projects into a true circle on the map. The projected geodesic is always concave to the pole of projection, and the angle between curve and chord is half the spherical excess of the triangle formed by the chord with the pole. The ratio of chord error to corresponding distance on the sphere or

$$\triangle s/s = \{r_m{}^2 + \tfrac{1}{12}s^2\}/4R^2$$

where r_m is the radius from pole of projection to the middle of the chord—the simplest of all the expressions except for the Zenithal Equidistant. If a Stereographic Projection had been used for Madagascar its greatest radius would have been about $6\frac{3}{4}°$ equivalent to a maximum scale error of $\pm\frac{1}{580}$. This is more than double the maximum error of Commandant Laborde's projection of 1/1453, but the labour of computation to find the errors is very much less than half, and such a radius would just include the neighbouring point of Mozambique on the mainland with which a trigonometrical connection will no doubt be made in the future. Otherwise a Gauss Conformal Projection might have been used with a maximum error of about 1/1200, only one-sixth higher than Laborde's, but with again a considerable saving in labour of computation.

Commandant Laborde is engaged on further researches in the general theory of map projections which we understand will be published shortly. We shall await these further results with interest. A. E. YOUNG.

Note.—Mr. Young has gone further into the matter since the above review was written, and following M. Laborde's lines, has obtained, he thinks, the formulae for the most General Conformal Projection without the restriction of Lagrange that the projected graticules should be true circles in known functions. A short account of this result was presented to the Projections Commission of the International Union of Geodesy and Geophysics at Stockholm, on August 15, and it is hoped shortly to publish fuller details of it.—Ed. *G.J.*

REVIEWS

CHAPTERS ON THE GEOLOGY OF SCOTLAND. By the late BENJAMIN NEEVE PEACH and the late JOHN HORNE. *Oxford: University Press* 1930. 10×6 *inches;* xvi+232 *pages; illustrations, diagrams, and maps.* 10s 6d

After the retirement of Peach and Horne from the Geological Survey they began the compilation of a joint work on the Geology of Scotland, which would have been of high value, as upon that subject they were the supreme authorities. The progress of the work was however blocked by fundamental disagreement on the early sections of the subject. After the death of Peach, Horne resumed work on the book, and he died leaving a few chapters which show how valuable the whole work would have been.

The first chapter is on the Physiography; it is accompanied by beautiful illustrations of the peneplanes which are well developed at various levels, and includes an excellent account of the evolution of the Scottish river system. The authors here adopt the former Clyde–Tweed river, which was suggested by Mackinder, and they appear to have abandoned the alternative which they proposed when the difficulties in the former outlet of the Clyde through the Tweed were removed by the present writer. Peach and Horne were vigorous champions of glacial erosion and they reject the tectonic explanation of the fiord valleys of Western Scotland; they attribute these valleys to denudation in pre-glacial times, with some modification by glacial action. That these valleys were due to ordinary river erosion appears even more inexplicable than that they were formed by glacial erosion. The alternative view that the fiord valleys are representatives of a type that is widespread and that they are of the same nature as some equatorial lakes is supported by the authors' admissions that the fiord valleys are pre-glacial, and that the Minch and the Sound between Skye and the mainland are due in part to earth-movements. The advance of the tectonic view may be illustrated by reference to H. G. Backlund's recent paper on the Fiords of North-East Greenland (*Meddel. Grönland.*, vol. 74, 1930, pp. 283–94), which attributes them to repeated earth movements that began long before glacial times.

Chapters II–IV, on the older rocks of the Scottish Highlands, include a most valuable summary of the geology of these early formations. They are well illustrated, masterly summaries of the present evidence, and explain clearly the various points of view. Thus the age of the schists of sedimentary origin such as the Loch Maree, which have been claimed as the oldest rocks in the British Isles, is left undetermined, and the reader is warned that the view that the rocks of the Highland Border series may be Cambrian and include a representative of the Stinchar Limestone of the Girvan district, though advocated by Peach in the latter part of the book, is unsupported by palaeontological evidence. The retention of the Durness Limestone in the Cambrian is an instance of the authors' conservatism.

The last two chapters are by Peach, and their nomenclature and views are inconsistent with those adopted in the preceding chapters. Peach rejects the term "Dalradian," as a geological division; he does not accept the Moine; and he classifies the schists of Central and Southern Scotland as Torridonian, Cambrian, Ordovician, and Silurian. It is true that he prefixes each name with a query; but that qualification is dropped in the statement of Peach's views in the editors' Appendix (p. 225). This view was provisionally adopted by Lapworth and Geikie; but they both abandoned it, and it appears quite inconsistent with the trend of recent work. It is explained in the text in a statement of Peach's view by Horne, who adds objections which appear unanswerable.

This part of the work will be of great value as a contribution to the history of

Scottish Geology; for Peach's opinions have had a great influence on his colleagues and this record of them therefore explains some tendencies in Scottish pre-Cambrian geology which would in years to come have been otherwise unintelligible. J. W. G.

A WAYFARER ON THE RHINE. By MALCOLM LETTS. *London: Methuen & Co.* 1930. 8×5 *inches;* xxii+246 *pages; illustrations and maps.* 7*s* 6*d*

The Rhine will always have its fascination for travellers, and Mr. Letts, who spent some of his school-days at Kreuznach, near Bingen, is well qualified to write about it. The book is a sympathetic study of the whole Rhineland. The historical association, or legend, of each place is given at some length, but the practical side is not neglected. Walks in the delightful valleys, easy ascents of the hills, short excursions on the Moselle and Nahe are provided for. The author suggests that the only part of the river worth traversing by boat is from Bonn to Bingen. There are chapters also on Frankfort, Heidelberg, Speyer, and Worms: it is sad to learn that much of the lovely Neckar valley is likely to be desecrated in the interests of commerce.

Not every one perhaps will like the rather long quotations, but they give the book a certain value and make it useful, not only for the ordinary tourist, but also for those who have time to linger. There are some good illustrations and sketch-maps. A. W. S

PALESTINE IN PICTURE. With an Introduction by CANON C. E. RAVEN. *Cambridge: W. Heffer & Sons* 1929. 12×9 *inches;* xii+230 *pages; and illustrations.* 10*s* 6*d*

PALÄSTINA: Die Landschaft in Karten und Bildern. By ROBERT P. KOEPPEL. *Tübingen: J. C. B. Mohr (Paul Siebeck)* 1930. 11×8 *inches;* vi+174 *pages; illustrations and maps. M.*18

PALESTINA: Visioni del Mondo. By ROBERTO ALMAGIÀ. *Rome: Luciano Morpurgo* 1930. 10×7 *inches;* 140+[216] *pages; illustrations and maps. Lire* 75

These three volumes of illustrations are remarkable in their contrasts. While all are concerned with Palestine, each views it from a different angle. There is among the many hundreds of pictures scarcely a duplicate. In the English volume the pictures are very clear and are most successfully reproduced. It will be found a drawback however that the titles of the illustrations are in a separate index in a pocket at the end. The photographs are all from foreign sources—Syrian, Armenian, German, and Jewish—and the book has been printed in Germany. The whole collection makes a volume of great interest to tourists and others who have visited the Holy Land. The introduction is brief and ordinary.

The German volume 'Palästina' is a more scientific work, and the pictures are inserted to illustrate the geology and physical geography of the land, rather than for their artistic merit. Many are from air photographs, and for this reason alone are remarkable. The notes are brief and to the point and are illustrated by several maps. A list of recent works—books, maps, and pictures—is given at the end of the volume. Of the many books on Palestine nothing published in England, and known to the present writer, covers quite the same ground.

The Italian volume again has a sphere of its own. The pictures are beautiful and full of romantic spirit. Jewish colonies, as in the English volume, are much to the fore. Portraits and groups of figures are particularly successful. One might say that ethnology here takes the place of geology in the German book and scenery in the English. A preface of 139 pages gives a full description of the land. In many ways this is the most individual volume and the illustrations are both

more original and more truly artistic than in either of the other books. Of the three it will certainly appeal most to the ordinary reader. E. W. G. M.

FOREST LIFE AND ADVENTURES IN THE MALAY ARCHIPELAGO. By ERIC MJÖBERG. Translated from the Swedish by ANNA BARWELL. *London: George Allen and Unwin* 1930. 9×6 *inches; 202 pages; illustrations and map.* 12*s* 6*d*

The island of Borneo is still an inviting field for the naturalist, and Dr. Eric Mjöberg has done well to give special prominence to it in this record of his eight years' exploration and research in the forests of Malaya. In Borneo alone he covered 1750 miles, and his travels included expeditions to the hitherto unexplored Mount Murud in Sarawak, and Mount Tibang in Dutch Borneo. His chief interest was in the fauna of the island, and in this sphere his work will take its place beside Prof. Poulton's 'Naturalist in Borneo' and the zoological writings of the late Dr. Charles Hose; while in his notes on flora the botanist will find a useful complement to the works of St. John, Whitehead, and Burbidge. The book is admirably arranged in a series of short chapters, each dealing with a specific subject: for example, the orang-utan, the pangolin, the goat-antelope, edible birds' nests, pitcher plants, sago. The text is illustrated by a number of excellent photographs, and while the book is the work of a mind trained to scientific observation and disciplined to patient investigation, it is written with such clarity that it can be read with pleasure by the layman; more especially since Dr. Mjöberg has not been treated ill by his translator, save for an occasional awkward phrase. We could have wished that he had seen fit to give us a more detailed account of his own travels; the expedition to Mount Tibang, by way of the Kajau and Mahakam Rivers, was made through little-known country and a description of it would have been of considerable interest.

Dr. Mjöberg ends his book with some "advice and hints to my successors"; these are mainly conventional generalizations, and the author, with his long experience, should have been able to provide some advice less obvious than that which, *inter alia*, states that "any one out for scientific research and proposing to take long forest expeditions must be properly equipped for this object." O. R.

THE BASIC INDUSTRIES AND SOCIAL HISTORY OF JAPAN, 1914–1918. By USHISABURO KOBAYASHI. *New Haven: Yale University Press (London: Humphrey Milford) for Carnegie Endowment for International Peace: Division of Economics and History* 1930. 10×7 *inches;* x+280 *pages.* 15*s*

This book is intended primarily for the economist and the student of social history, rather than for the geographer. It is divided into four parts. The first deals with agriculture, the most important sections being concerned with rice and silk, the regulation of the prices of these commodities, and the effect of the Great War on agriculture. The second part is devoted to mining and metallurgy and is similarly arranged. The third is a discussion of forestry and fisheries, and the last describes economic measures and the social results of these measures and of the War generally. For the geographer the chief interest lies in the effect of the breakdown of modern transportation owing to the War and the utilization and development of native resources under the spur of necessity. The book is full of figures and tables, many of which would have been much more clearly set out by graphs, the omission of which is a serious defect. A map or two should also have been inserted and would have made clearer much of the text. There is no index.

L. H. D. B.

AFRICA AS I HAVE KNOWN IT: Nyasaland, East Africa, Liberia, Senegal. By R. C. F. MAUGHAM. *London: John Murray* 1929. 9×6 *inches;* xii+372 *pages; illustrations and maps.* 21*s*

Mr. Maugham's services in Africa began in 1894 and lasted until 1928. He went out to Nyasaland, as head of the secretariat, when the period of partition was scarcely ended, and there is nothing better in his book than the account of the two years he spent in Nyasaland, with an infant European (and largely Scottish) community still battling against Arab slavers and hostile natives. In those days soldiers and civilians alike had to fight, and Maugham had to his credit the capture, by a daring ruse, of a formidable Angoni chief. On leaving Nyasaland the author held consular appointments for many years in Portuguese East Africa, and it is clear that his chief memories and his greatest sympathy are of and with East Central Africa. Indeed, while his book is mainly an account of personal experiences, he devotes a chapter to the early history of East Africa, and another chapter to a consideration of the native tribes. Later Maugham was Consul-General in Liberia, of which republic he draws a gloomy picture, and, finally, he was Consul-General for French West Africa. Throughout his career he showed himself capable, enterprising, resourceful, observant, a firm upholder of British interests, and a man who understood and sympathized with the African. He is among those who believe in the development of the African peoples upon native lines; though fully aware of the magnificent work done by Christian missions, he has still lingering doubts about mission " boys."

Much of the appeal of this book lies in its revelation of conditions in the pioneering days, in the author's gift of describing scenery, and in the account of strange happenings. Of this last character was his visit to Maravi the Outlaw—whose residence was approached through an avenue of poles each surmounted by a human skull, and those the skulls of Portuguese. There are too a number of good stories, laughter provoking, such as the homesickness which fell on the Dutchman at the sight of a big mountain. It reminded him, he said, of his wife—"Mine Alma is beeg like dat."

In his introductory chapter the author falls into errors. The whole account of the exploration of East Africa needs revision, for Mr. Maugham states that Livingstone was the discoverer of Lake Tanganyika and that Burton and Speke were sent out as the result of Livingstone's discoveries. And he repeats the well-worn mistake as to the decision of the Berlin Conference of 1884–85 concerning sovereignty and effective occupation. The decision of the conference applied only to coast lands. It is true that, with frontiers undetermined, effective occupation (even occupation not effective) of inland regions played a part—as in the case of Portugal—in the final settlement, but the partition of Africa was in the main accomplished in Europe by lines drawn on the map. F. R. C.

THE RISE OF THE SOKOTO FULANI: being a Paraphrase and in some part a Translation of the 'Infaku'l Maisuri' of Sultan Mohammed BELLO. By E. J. ARNETT. (*Kano: Emirate Printing Department* 1922.) 10×7 *inches;* iv, 140+44 *pages; and maps*

The existence of the 'Infaku'l Maisuri' was first made known by Clapperton, who gave extracts from it in his 'Travels and Discoveries.' Barth also examined a copy, but, like his predecessor, he failed to appreciate the unique interest of a contemporary account of the Fulani *jihad* by one who, as the son of Usuman, played a leading part in this stirring episode in the history of the Western Sudan. Had either traveller been able to guess that one day the Fulani dominions would fall under the Government which they both served, their attitude towards the 'Infaku'l Maisuri' would have been very different.

Mr. Arnett's translation of a Hausa version of Bello's work forms a valuable contribution to the literature of the Western Sudan. Bello's simple narrative inevitably excites admiration for the Fulani and for the fervour of their leader. Mr. Arnett, who by his many years' service in the Emirates of Northern Nigeria, particularly as Resident of Sokoto, is especially qualified to write of the Fulani, has been unable to decide whether race or religion was the more important factor in the *jihad*. But Bello's book, he points out, "demonstrates clearly the absolute sincerity of Sheikh Usuman, which is also attested by the reverence attaching to his memory and the number of devout pilgrims of different tribes and races who annually visit his tomb at Sokoto."

Although the 'Infaku'l,' in common with other historical works of a similar nature, is often rather dry reading, its pages are full of interesting information which will prove invaluable to students of history and to administrative officers. Thanks to Mr. Arnett's industry it is now possible to trace out the complete story of the *jihad* and to sift historical facts from the many legends to which a national movement of this nature inevitably gives rise.

It is to be hoped that the words "Kano Emirate Printing Department" so unobtrusively printed in very small type on the back cover will not escape the notice of those who may be disposed to cavil at the format and rather numerous printer's errors. In reality the book is a highly creditable product of modern Fulani enterprise, for it has been printed in spare time on the Emir of Kano's press, which is primarily intended for printing official forms, etc. That it is possible for the natives of Kano to produce a book such as this also reflects very great credit on the Administration of which Mr. Arnett is such a distinguished representative. E. W. B.

EXPLORATION OF THE GULF OF ST. LAWRENCE 1499–1525. By G. R. F. Prowse. Two Parts. *Winnipeg: Mimeographed by the Author* 1929. 14 × 9 *inches;* 24 *pages of text and* 14 *pages of maps.* $1

In 1899 Mr. G. R. F. Prowse announced a comprehensive work on the early cartography of the Gulf of St. Lawrence from Cabot to Champlain. This is the first instalment, but the text is very succinct and the proofs for the most part wanting. The author's idea appears to be to divide all the maps of these regions, no matter what their dates, into families according to their outlines. These are then subdivided into sections which show common nomenclatures or configurations. From these classes the author then proceeds to deduce certain voyages of exploration to those parts, whether any record exists or not.

Leaving out Cabot's first voyage, Mr. Prowse is convinced that "a London ship was sent out secretly by Henry VII after Cabot's return in August 1497. The landfall was in Conception Bay on December 8. The voyage extended to near Cape Ray." If Mr. Prowse had studied John Cabot's patent he would have seen that such a voyage from London was prohibited. Moreover Mr. Prowse is convinced that he has "deciphered two London, one Yorkshire and three Bristol voyages up to 1500. Several were made simultaneously and the results at once integrated and coordinated so as to adjust the overlapping." Since "England had no School of Pilots and Mapmakers until at the earliest 1514 the logs of the early English seamen had to be sent to Lisbon or Seville to be reduced to proper hydrographical form. The resulting charts were published with the coastal names in Portuguese or Spanish."

To the ordinary student the conclusion from the facts we know would seem just the opposite. We know the Portuguese visited these parts, and the maps bearing Portuguese names must have been compiled by Portuguese. Even for John Cabot's voyage the only map we have is that of Juan de La Cosa. Mr.

Prowse uses this, but to prove what he calls a Cosa voyage or "an English discovery of the Gulf about 1500" which the explorers tried to keep secret. In fact all these voyages must have been secret, for there is no mention of them in any of our records.

In addition to the above Mr. Prowse thinks he finds proof of a French exploration of the Gulf about 1525, so that Cartier was not the first French explorer. Thus the bay de Chaleur when Cartier reached it "was recognized either from a chart or by one of the crew who had been there before." Similarly Seven Islands was so named after the Seven Sleepers by an English explorer much before Cartier's time. Both these assertions rest merely on the author's *ipse dixit*. Chaleur Bay was so named by Cartier on account of the heat, and the Seven Islands were so named after a similar group to the west of St. Malo.

In reality Mr. Prowse's method is totally unscientific. "Throughout this study," he tells us, "the language of the place-names, the nationality of the map-maker and the date of the map have been deliberately ignored." Surely this is hardly the way to approach such a subject?

Where he has sought to identify an old map on our modern chart he seems to go very much astray. He is of opinion, for instance, that the Cantino map extends from Sandwich Bay to Cape Anguille, notwithstanding the fact that the northern point is almost opposite to Cape Farewell, and that the Reinel map actually shows latitudes. He has stated in the same article that the Latin inscription on the Thorne map of 1527, *Terra hec ab Inglis primum fuit inventa*, covers the whole coast from Cape Chidley to Cape Sable. Had he placed this map in its true family he would have seen that it is merely Thorne's rough draft of the Ribero map and that this inscription on Thorne's *Nova Terra Laboratorum dicta* is merely the Latin for Ribero's *Tierra del Labrador. Esta Tierra descubrieron los Ingleses*, which is restricted to our Greenland, then called Labrador. Moreover Thorne in his text actually states that this is the case; but unfortunately Mr. Prowse has not read the documents.

His second volume reproduces rough drawings of the map families to illustrate his theories.

FORESTRY: A study of its origin, application and significance in the United States. By A. B. RECKNAGEL and S. N. SPRING. *New York: Alfred A. Knoff* 1929. 8×5 *inches;* x+256+xxxviii *pages; and illustrations.* 10*s* 6*d*

This book is a study of the origin, application, and significance of forestry in the United States. The problem of timber production by forestry methods is discussed in several chapters, the outlook being mainly economic. The essential need of timber in all its numerous forms in our modern world calls for a policy of forest conservation and, in certain areas, reafforestation. The authors make it clear that they consider that suitable cutting is the best way to prolong the life and usefulness of these forests, as long as other trees are planted to take the place of those cut down. They describe the scientific methods followed by certain private firms and by the State and Federal Governments. They also emphasize the necessity of educating the youth of the land in matters pertaining to the upkeep of forests. There is a complete change of mind from the days when forests in America were obstacles to be cleared as soon as possible. Now they are precious possessions, to be guarded jealously from fire, browsing animals, reckless cutters and so forth.

The subject is a fascinating one, but the reviewer finds this book rather dull, in spite of the large amount of careful work that has been put into it. It is very heavy for its size and seems unduly expensive. A. B.

HISTOIRE DES PEUPLES SHOSHONES-AZTÈQUES (Amérique du Nord et Amérique Centrale). By JEAN GENET. *Paris: Les Editions Genet* 1929. 9×6 *inches; 352 pages; and sketch-maps.* 60 *fr.*

HISTOIRE DES PEUPLES MAYAS-QUICHÉS (Mexique, Guatémala, Honduras). By GENET and CHELBATZ. *Paris: Les Editions Genet* 1927. 9×6 *inches; 256 pages; and sketch-maps.* 40 *fr.*

Students of the obscure history of pre-Columbian America owe to M. Genet a debt for the work already accomplished as part of his extensive programme, the publication of a series of texts "relative to the ancient civilizations of Mexico and of Central America." Of this series, Bishop Diego de Landa's 'Relación de las Cosas de Yucatan,' the curious 'Popol-Vuh,' or "Sacred Book" of the Quichés, and Antonio de Leon y Gama's 'Descripción de la Ciudad de Mejico,' have already been issued or prepared for the press; and M. Genet proposes to follow these with the texts of early Spanish historians, such as Herrera, Gomara, Motolinia, and Cogolludo, amongst others. The whole will form a monumental collection, invaluable to every worker in this field. Some of the manuscripts have never been published; in other cases no modern edition exists, and of certain older publications only a few copies are scattered throughout the museums of the world.

Apart from the reprint of rare accounts of Mexico and Central America written by European observers, M. Genet issues monographs upon phases of the subject: 'Les Ruines de Mayapan,' 'Le Roi Quiché Cotuha,' 'L'Histoire Tzutuhile,' 'Notes sur l'Histoire du Guatemala,' and 'Le Yucatan à travers les âges,' have been already issued or prepared; and the present volume, reviewing the story of the Shoshone–Aztec group of indigenous American peoples, is another work from the indefatigable hands of the same author.

The group is linked by linguistics rather than by other definite connections, and formerly spread, in the course of tribal movements, between the southern border of Canada and the Isthmus of Panama. Adopting and simplifying, in the fertile Valley of Mexico which they occupied after conquering the Maya inhabitants, a remarkably accurate calendrical system, and a system of recording by means of pictographs, the Aztec people had enjoyed more than a century and a half of settled life before the coming of the Spaniards in 1519; few of the Aztec manuscripts survive, and it is usual to blame the first Bishop of Mexico, Zumarraga, for the wholesale burning of priceless records. But M. Genet reminds us that two Aztec rulers had previously, for reasons of their own, ordered the destruction of documents.

M. Genet covers the period of the Spanish conquest and the overthrow of Aztec leadership, and gives succinct accounts of the religions of the different groups in their primitive condition. The volume is well documented, and a useful bibliography is added.

The story of the Maya-Quiché folk, indicated by the magnificence of the ruins whose carved stones still stand amongst the forests of Central America, would be in its entirety the revelation of the rise and fall of a great religious and artistic community. It is only known in glimpses, however, and the evidence of these has been gathered together by M. Genet with the help of M. Chelbatz.

Much reliance is necessarily placed upon the writings of Spaniards immediately after the subjugation of Yucatan and Central America, and of the intelligent men of native blood who were trained by Spaniards and encouraged to write down the traditions of their race. To Bishop Landa, who destroyed so many Yucatec records, the modern archaeologist nevertheless is indebted for including in his own accounts of the country copies of certain glyphs and their meaning in Spanish; without this aid the task of reading Maya glyphs to-day, even to the limited extent now possible, would be frustrated.

Traditions of the confederations of the Maya divisions, the tribal quarrels and migrations, before the Spanish Conquest, form a coherent narrative upon which one hopes, some day, for more light. M. Genet and his collaborator quote from all the great Spanish historical sources, as well as the curious legendary Books of Chilan-Balam and the Popol-Vuh; authorities are carefully named. There is a bibliography, but it is unfortunate for readers that the Editions Genet are not indexed. L. E. E.

GRENZPROBLEME UND FORSCHUNGSREISEN IN PATAGONIEN: Erinnerungsblätter aus der Zeit des chilenisch-argentinischen Grenzkonfliktes. By HANS STEFFEN. *Stuttgart: Strecker und Schröder* 1929. 10×7 *inches;* viii+296 *pages; illustrations and maps. R.M.*20 (*bound* 24)

The demarcation of the boundary between Argentina and Chile was completed and settled by Award over a quarter of a century ago, on the basis of the work carried out in the field by the Commission under the leadership of Sir Thomas Holdich. One is now apt to feel a little impatient with a protagonist, no matter how expert and entitled to voice his views, of one of the countries to the agreement—in this instance Chile—who selects those sections of the terrain where the boundary as fixed does not please him, to show how that country has been wronged.

Dr. Steffen was at one time Professor in the University of Santiago, and while resident in Chile undertook extensive journeys in company with Government survey parties in the Cordilleran and adjoining fiord and Patagonian Plateau regions of Southern South America during the years 1893 to 1902, thus coming earlier on the scene than the Boundary Commission. His book, written many years later in Europe, is mainly a detailed account of these journeys and of the observations made at the time. He worked in a fascinating field, was in the way of being a pioneer, and brought to his task ample knowledge. In reading his account one is struck by the extraordinary complications of relief and drainage in this wilderness so recently and still partly glaciated to sea-level, by the difficulties of communication by land on the Chilean side, and by the extent of high mountain country that must for long remain unexplored. The boundary, whether it follows the watershed or the main Andean Chain, or compromises between the two, is apt to leave Chile a strip in which the only means of intercommunication is by sea between one rocky point, one fiord, or one cañon-like river valley and another.

Dr. Steffen has produced a work of scientific merit on a region the inner parts of which are little known. His partisanship is perhaps excusable. When he puts on his impartial scientific mantle, he gives us clear and well-informed accounts of district after district in his wide field, to which accounts the various specially prepared sketch-maps serve as useful illustrations. E. W. S.

A STORY OF A HUNDRED YEARS: Western Australia 1829–1929. Edited by Sir HAL COLEBATCH. *Perth, W.A.: Fred Wm. Simpson* (*Government Printer*) 1929. 10×6 *inches;* x+476 *pages; illustrations and maps.* 12*s* 6*d*

Western Australia has a rather more modest story to tell of material achievement during the last hundred years than have the Eastern States or New Zealand, but no less credit is due to her, considering the difficulties which she has had to face. In this well-filled volume the story is told of these obstacles and of the ways in which they have been surmounted. With their own peculiar environment, their distance from the main centres of population in the Commonwealth, and their rather distinct economic life and problems, it is little wonder that the people of Western Australia—more accurately of South-Western Australia—

should have developed a strong local patriotism, of which this centenary book is evidence.

The story of colonization and the development however is a drama that has been moulded throughout by the setting of the stage on which it has been played, namely the environment. This, which has received ample treatment in the present volume, is naturally of chief interest to geographers at large. Attention is given in separate chapters to such subjects as climatic conditions, flora, fauna, and mineral resources; the more remote and less well-known districts, for example the Kimberleys, are carefully described; and economic geography under the headings of the various industries receives, as might be expected in a work of this kind, a full share of space. The illustrations are a special feature. Apart from several coloured plates showing the wealth of wild flowers in the state, almost all are reproductions of drawings which have some claim to artistic merit and lend an air of distinction to the general get-up. A good deal of the matter in the text can have little more than a local interest, but the work as a whole will prove an excellent up-to-date source book for matters relating to the history and geography and to the whole economic life of Western Australia. E. W. S.

MAN AND ANIMALS IN THE NEW HEBRIDES. By JOHN R. BAKER. *London: Routledge & Sons* 1929. 9×6 *inches;* xiv+200 *pages; illustrations and sketch-maps.* 12*s* 6*d*

To mention the New Hebrides calls up, in the minds of most people who recognize the name at all, memories perhaps of Quiros and his visionary austral continent, certainly of Anglo-French rivalry, repeated scares about annexation, and the clumsy Condominium which has temporarily allayed the rivalry and ended the scares. Mr. Baker's detailed but interesting record of his visits to the group presents it in quite a new light—as a museum both of rare species (some not known to exist nearer than South America) and of unique tribal customs. Mr. Baker is primarily a zoologist, but he is also an explorer, the first serious investigator of the great lake in Gaua, the first European to climb Mount Tabwemasana, and to discover that its farther peak is really the highest mountain in the New Hebrides. His researches, moreover, whether geographical or ethnological, are continually raising fresh problems of great interest, such as why the natives are dying off, how fringing coral-reefs are really formed, and how certain members of the fauna (snakes, for instance, and polychaetes) reached the Western Pacific from their normal American habitat. For scientific students therefore this book, which is essentially an expansion of the paper read before the Society by Mr. Baker in January 1929 and published in the *Journal* for April 1929 (vol. 78, pp. 305–325), has considerable interest and value; politically-minded readers will find it lacking in information about the Condominium, or European land-settlement in the group, or harbours of strategic importance. This last comment is, of course, a warning to such readers and in no way a criticism of Mr. Baker's work. A. J.

REPORT ON THE GEOLOGICAL COLLECTIONS made during the voyage of the *Quest* on the Shackleton-Rowett Expedition to the South Atlantic and Weddell Sea in 1921–1922. Issued by British Museum (Natural History). *London: Trustees of the British Museum* 1930. 10×6 *inches;* vi+162 *pages; illustrations and maps.* 12*s* 6*d*

The last expedition organized by Sir Ernest Shackleton sailed in a small wooden vessel, the *Quest*, to investigate the islands of the South Atlantic and adjacent parts of the Antarctic. The tragic death of the leader off South Georgia in January 1922 led to a curtailment of the voyage; but the *Quest* visited a number

of the islands and, owing to the energy of Mr. G. Vibert Douglas, valuable geological collections and observations were made. These collections were presented to the British Natural History Museum by Mr. Rowett and have been described in an important series of papers published by the British Museum in one volume edited by Mr. Campbell Smith.

The material from South Georgia is especially instructive. Mr. Douglas collected a piece of fossil wood that is described by Professor Gordon as *Dadoxylon* (*Araucarioxylon*); its age is regarded as "rather Mesozoic," though it might be Upper Paleozoic. The geology of South Georgia is described and discussed by Mr. Douglas and Dr. G. W. Tyrrell. The South Georgia problem is still left uncertain, for, as Dr. Tyrrell remarks, the age of the rocks can only be settled by fossils, and no additions were made to the older series collected by Mr. D. Ferguson. The geology of the island is complicated by changes in the names of the localities where Ferguson collected and of his divisions; thus his Cape George Series is renamed the Godthul Harbour Series, and Port Gladstone has been renamed Prince Olaf Harbour. Mr. Ferguson's conclusions as to the structure of South Georgia have been adversely criticized, and the tendency has been to regard all the sedimentary rocks as of Mesozoic age, instead of being in part Ordovician or Silurian, and in part Mesozoic. Dr. Tyrrell and Mr. Douglas both accept the presence of two sedimentary series; and Mr. Douglas, after a careful examination on the field, says it is difficult to reject Ferguson's views that the two are separated by an unconformity. Some fossils found by Mr. Ferguson in the lower part of his Cumberland Bay Series were identified by Ulrich and Bassler as *Camarocladia*, and they seem to render impossible the reference of that part to any age later than Silurian. The Ammonite came from the upper sediments, to which Dr. Tyrrell restricts the name Cumberland Bay Series; this series consists of shales and tuffs and includes detrital material from the igneous complex at the south-eastern end of South Georgia; hence those igneous rocks, gabbros, spilites, etc., are earlier than the Mesozoic sediments. Similar rocks occur in the Western Argentine and are assigned by their describer, H. G. Backlund, to the Rhaetic or Lias; they apparently belong to the pre-Cambrian foundation and give no support to the view of Suess that South Georgia was part of an Andean arc. The typical igneous rocks of the Andes are still unknown on South Georgia.

Amongst other additions to the geology of the South Atlantic islands Dr. Tilley shows that Elephant Island in the South Shetlands contains albite-schists similar to those of the Dalradian rocks of Scotland. Mr. Douglas and Mr. Campbell Smith show that Zavodovskii Island in the South Sandwich Group, from specimens dredged near it, as landing was impossible, is basalt, and that dredging in the Weddell Sea yielded slate, quartzite, greywacke, gneiss, and other continental rocks. Tristan da Cunha appears to be entirely volcanic and there is nothing to disprove the expectation that the granite collected there by H.M.S. *Odin* had been introduced from ship's ballast. Mr. Campbell Smith identifies the rocks of Gough Island as largely alkali-trachytes and trachy-basalts similar to those of East Africa, and the specimens from St. Helena and Ascension as having similar geographical affinities.

The collection includes a wehrlitic dunite from St. Paul's Rocks, 540 miles east of Brazil; it is described and discussed by Dr. H. S. Washington. The rock judged from its own characters is a metamorphic or crushed plutonic rock; it includes such characteristic metamorphic minerals as jadeite and actinolite, and has streaks typical of pressure metamorphism. Dr. Washington discusses in detail the possibility that the rock may be a lava, for which the only recommendation is its oceanic position. Though he attaches great weight to that factor, he

concludes that the St. Paul's Rocks are a part of the Atlantic floor raised above sea-level.

Miss Vibert Douglas describes the deep-sea deposits and identifies among those of the South Atlantic pebbles of aegerine-granite, which is also a typical representative of the Atlantic igneous rocks. J. W. G.

METHODS IN GEOLOGICAL SURVEYING. By E. GREENLY and H. WILLIAMS. *London: Thomas Murby & Co.* 1930. 9×6 *inches;* xvi+420 *pages; illustrations, diagrams and maps.* 17*s* 6*d*

The title of this book scarcely gives an adequate clue to the breadth of the field covered by its contents. It is much more than a mere exposition of the methods employed in geological survey. The first eighty-four pages are devoted to maps in general and the evolution of general cartography. The treatment here is rather brief and sketchy and the geographer may doubt the value of these introductory chapters: whether, for example, any really useful information about conical projections can be conveyed in ten and a half lines, or of the history of maps from early Egyptian to modern times in ten pages. Chapter V has the ambitious title of "The Evolution of Cartographic Mathematics," but it only occupies a dozen pages. Chapter VIII completes Part I, and is an important chapter on the evolution of Geological Cartography, occupying thirty-eight pages. It deals not only with the history of geological maps but has short notes also on geological surveys of all countries in the world. In some ways, however brief, it is useful; but where the information has been tested some serious errors have been detected. Thus the Indian Geological Survey is criticized in that the maps proper have been issued in the volumes of "Memoirs" and "Records," and are on various scales. The authors state that "the systematic survey of the whole country would of course be scientifically (and probably, in the long run, economically) far better." They are evidently unaware that a very large area of India has been covered by systematic survey on the 1-inch scale. The sheets are hand-coloured and filed at the Central Offices of the Survey in Calcutta, or Rangoon in the case of Burma, and copies may be made by any geologist or copies may be purchased. Systematic survey of the country is regarded as the first duty of the majority of surveyors attached to the Geological Survey of India.

Part II, entitled "Geological Surveying," occupies the remainder of the book. There can be nothing but praise for this scholarly and at the same time eminently practical exposition of the aims and methods of geological surveying. No one needs to be reminded of Dr. Greenly's work in the island of Anglesey, a work which occupied nearly a quarter of a century and resulted in the elucidation of the geological history of an area which would have baffled one with less skill, patience, and attention to detail. The authors are magnanimous in their acknowledgment of the influence of others: of Peach, of Horne, of Clough, to the last of whom the book is dedicated; but one feels throughout that it is Anglesey which has been the real master and the real teacher. Such a book as this should go far in counteracting a tendency towards careless or slip-shod methods in geological mapping, and for that reason it deserves the serious attention of every student of geology. At the same time the dual authorship has produced a book with an extremely broad outlook. Dr. Howel Williams has had personal experience of modern and pioneer methods in the west of America, so that a geologist making a first survey of new lands will not find his point of view neglected. There is a full and excellent bibliography, brought quite up to date, including, as it does, the principal modern papers on geophysical methods of surveying. Indeed, only the possibilities of aerial surveying seem to have escaped attention. The book is well produced and only the plates lack clarity. L. D. S.

FORMER GLACIATION IN THE APENNINES

Certain writers in Italy have lately put forward the view that the glaciation of the Apennines in the ice age was much more extensive than had previously been supposed. In order to test the truth of this view Professor R. von Klebelsberg of Innsbruck has lately carried out investigations on the ground, beginning with the region of the Gran Sasso and Majella in the Abruzzi, where ice-age glaciation was first established by Partsch in 1889 and Hassert in 1900. A somewhat detailed account of his observations, with a short summary of conclusions, is given by him in the June number of the *Zeitschrift für Gletscherkunde*, of which he is editor. So far he has found little to substantiate the extreme views referred to, for what have been put down as glacial deposits have in some cases been established as such by no firm evidence. That there was a marked depression of the snow-line in the ice age admits of no question, and the writer estimates its amount in the district examined as reaching a maximum of 1700 metres. But the extent of the glaciers was still far below that shown by the Alps. Nowhere did a glacier pass out of the mountains on to the lowland, and only rarely were important valley glaciers developed. A reason for this is found in the morphology of the range, which offers no wide gathering-grounds for the ice. It is only on the north side of the Gran Sasso that true high-level valleys exist.

A RECENT GLACIER IN THE URAL

The same number of the *Zeitschrift* describes the discovery in the Northern Ural, by a geological expedition under A. Aleshkov, of an existing glacier in the Sablya range in 64°–65° N. This has caused some surprise both because it had been thought that the Ural possessed no permanent ice, and because this part of the range was fairly well known. The glacier occupies a cirque with a diameter of 600–650 m. and sends down a distinct ice-tongue to an elevation of 700 m. Two small nevé glaciers were also found.

FOG BELTS AND VEGETATION IN ALGERIAN MOUNTAINS

An instructive example of the efficiency of fog in supplying moisture to vegetation is described by H. Prat in an article entitled "Influence des Brouillards sur la Végétation du Djebel Murdjadjo," appearing in the *Bull. Trimestr. de la Société de Géographie et d'Archéologie d'Oran* (t. 50, 3^{e} et 4^{e} trim. 1929). The Jebel Murjajo is a range near Oran. It is a National Reserve, so its vegetation is protected from the ravages of animals, and hence is easier to study in its climatic relations. At the eastern end of the range there is a cirque exposed to the east and south forming the steep side of the Almeida plateau, and approached from the north or seaward side of the range by a col which separates the range from the high ground of Pic d'Aidur and Fort de Santa Cruz. The whole slope of the cirque is too steep to retain much rain-water, but whereas the lower part is practically destitute of vegetation the upper bears quite a thick covering of plants of a more or less xerophilous character. The author, who has made many visits to the districts at all seasons of the year, finds that the lower limit of the vegetation coincides precisely with the lower limit of the mists which develop in the evening after a hot day, and sweep through the col on to the higher parts of the cirque. The mist is prevented from enveloping the bottom of the amphitheatre by hot air currents which dissolve it. Weather of the kind in question occurs with great constancy in the climate of North Africa, and the vegetation in the fog zone doubtless collects considerable quantities of moisture from the fog at night time. The northern side of the Jebel Murjajo, sheltered from the fierce sun and facing

the moisture-laden sea-winds, carries, on the contrary, a luxuriant hygrophilous vegetation. This points to a heavier rainfall on the northern side of the range, but no direct reference is made by the author to this factor. The reader is assisted by a map of the eastern end of the Jebel Murjajo, and a plan of the configuration of the district under discussion showing the course taken by the fog-laden air-currents through the col.

NIAMEY, CAPITAL OF THE FRENCH NIGER COLONY

The June 1930 number of *Renseignements Coloniaux* contains an account of this town, situated on the eastern bank of the Niger in 13° 31′ N. Lat., which, after being replaced for a time by Zinder, has again taken rank as capital of the Colonie du Niger. Its original choice was based on the need of a strong post in a strategic position in the early more unsettled days of the colony, the subsequent transfer to Zinder being suggested by the difficulty of controlling from Niamey the distant eastern parts of the territory. With the advent of the motor-car and aeroplane this difficulty is lessened, and economic considerations have led to the latest shifting. Apart from the importance of a position on the navigable Niger, Niamey lies at the crossing-place of the two main routes across French West Africa—that from the Mediterranean towards the Gulf of Guinea, and that from Dakar to Lake Chad—and in course of time it will become the focus of other routes radiating in all directions. Its position is important too in connection with a future Trans-Saharan railway, from which it is contemplated that a branch will be carried to connect here with the Kotonu-Niger railway already begun. Ambitious schemes have already been set on foot for the development of the capital on modern lines, a space of 6 kilometres by 5 having been set apart in the first instance for the purpose, in which avenues, squares, markets, a park, etc., will be laid out. Provision is also being made for future extensions, and for the development of the native quarter. The place will be the most important centre of French economic activity in the interior, nearly all of the existing towns of importance lying on the outer borders of the Territory.

ARCTIC PATROL BY THE ROYAL CANADIAN MOUNTED POLICE

The Department of the Interior in Canada have recently issued a description of "The North-West Territories, 1930," written by F. H. Kitto. Apart from useful and general information in regard to the Canadian Arctic, some account is also given of patrol work by the R.C.M. Police, more particularly in the Franklin District, from Baffin Land northwards. The 1929 patrol led by Inspector Joy is particularly notable. On March 12 he left headquarters at Dundas Harbour, Devon Island, accompanied by one constable, one Eskimo, and two dog teams. The route ran westerly to Winter Harbour on Melville Island, then northwards by Hecla and Griper Bay to Lougheed, Ellef Ringnes and Axel Heiberg islands. The travel difficulties were many: in places deep soft snow, rough ice for long distances, and much trouble with fractured ice-foot. Some stormy weather was encountered with stiff cold winds and heavy fog. For days at a time their clothing was wet and frozen and could not be dried out owing to lack of fuel. Supplies however were ample and there was no shortage of food: the party depended partly on hunting. Rough ice affected the dogs' feet, but only one dog was lost. Side excursions were made to examine interior parts of the islands visited; in this connection Vesey Hamilton Island, north of Melville Island, is described as of very remarkable formation, consisting of a series of high bare hills with sharp peaks and steep slopes, intercepted by narrow ravines. Inspector Joy says it has the appearance of a miniature Rocky Mountain area. From Axel Heiberg Island numerous side tracks were made, and in May the party crossed Ellesmere

Land and over glaciers to Beitstad Fjord; and finally on May 31 reached Bache Peninsula, the most northerly R.C.M.P. outpost. In eighty-one days the patrol had travelled a distance of over 1700 miles. Considering the difficulties of breaking trail, apart from the usual vicissitudes of ice travel and fitful weather, this journey is exceptional and ranks with the best records from Arctic and Antarctic. The average is over 20 miles per day. One of McClintock's longest journeys was to Prince Patrick Island in 1853, when 1030 miles were covered in 105 days. Mecham's well-known record for distance by man-haulage was 1157 geographical miles in seventy days, an average of 16·5 miles, or, allowing for travelling days lost, of nearly 19 geographical miles per day. It is not stated whether Inspector Joy's miles are geographical or statute; but in either case his rate appears to exceed Mecham's, and his advantage of dogs over men can be offset against the fact that Mecham on his journey from H.M.S. *Resolute* to Prince of Wales Strait was following a trail for the most part already known and in fairly constant use. Last year's journey though the longest is not the first undertaken by Inspector Joy; and for actual speed of travel his record is that of 1927, when his patrol from Bache Peninsula to Axel Heiberg and Cornwall islands covered 1300 miles in fifty-four days.

MOUNT KATMAI AND ITS REGION

The first detailed information on the effects of the great Katmai eruption of 1912 was due to the National Geographic Society's expeditions under Mr. R. F. Griggs, in the second of which, in 1919, Mr. C. N. Fenner and two other members of the Geophysical Laboratory participated. In 1923 Mr. Fenner was attached to a party of the U.S. Geological Survey in order to continue the study of the volcanic features of the mountain and its neighbourhood, and he describes the results of his observations in the June 1930 number of the *Zeitschrift für Vulkanologie*. The first ascents after the eruption were made from the south, and though the rim of the great crater was reached a descent to its floor seemed impossible. In 1923 the mountain was climbed from the side of the Valley of Ten Thousand Smokes on the north-west, an unknown mountainous tract having been traversed *en route*. Reaching the glacier on the slope of Katmai at an elevation of 3110 feet, Mr. Fenner and his assistant, Mr. Yori (an experienced mountaineer), proceeded up a smooth snow-covered slope to the rim of the crater. The original source of supply to this and other glaciers was on the upper part of the cone which was shattered by the eruption, and now that this supply is cut off they will probably dwindle in time. After some delay from fog the climbers found themselves at the head of a long snow slope by which the descent to the crater floor was safely effected, the difference in altitude shown by the aneroid being 1600 feet. In places however the walls rise to 2500 or 3500 feet. The most spectacular feature of the crater was a great mud geyser which erupted with loud detonations at short intervals, and steam and gases were rising elsewhere from the crater floor. When the mountain was first ascended a lake had occupied part of the floor, with a crescentic island in the middle, but in 1923 the lake was represented only by a lagoon within the crescent. The melting snow and ice on the surrounding heights caused copious cascades down the cliffs, but the water was not rising over the floor. Subsequently another of the volcanoes of the district, Mount Mageik, was climbed, and its crater too was explored in the face of some risk from crevasses and loose boulders poised threateningly on the ice-slopes. The walls of the crater were vertical, but a gap at the southern end allowed easy ingress. The width was only about 200 feet and the depth not much over 400. Mr. Fenner discusses the general geological features of the region in the light of his observations. He sees no evidence of any great fracture of the crust which might explain the linear

arrangement of the volcanoes. These, again, do not seem to have broken out along the summits of a high range, but the line of heights is more probably due to the protection afforded by the lavas poured out when the general surface was at the same general elevation. Stress is laid on the general horizontality of the sedimentary strata underlying the lavas, which tells against the idea that the region is one of overthrust and greatly folded mountain arcs such as are the Alps and Himalaya. Such evidences as exist of anticlinal structure are of much less importance than has been supposed, and vertical rather than tangential thrusts seem to have been dominant.

THE *SNELLIUS* OCEANOGRAPHICAL EXPEDITION

Two further reports on the work of this expedition (see *G.J.*, 75, 1930, p. 565) have appeared in the *Tijdschrift* of the Royal Netherlands Geographical Society (May and July 1930), and show that the cruises in Eastern waters have been continued with success and have yielded an equally rich harvest with those previously noted. The third and fourth cruises, in the last three months of 1929, took the observers to the waters in the east and south parts of the Malay Archipelago, beginning south of Halmahera and then through the Ceram Sea to the channels between New Guinea, the Kei, and Aru Islands; then turning west on the south side of Tanimber, Timor, Roti, and Sumba, with an examination of the channels separating the islands and of the Savu Sea enclosed between Timor, Sumba, and Flores. As before, the submarine contours were carefully studied by sounding (echo or other) and much new material was gained for a knowledge of the levels at which connection between the basins is effected, and the course of the submarine ridges. Observations of temperature, salinity, etc., were constantly made and threw light on the way in which the deep basins receive their supply of cold bottom-water. The bottom in the eastern part of the Ceram Sea proved exceedingly irregular, and echo-sounding alone gave no clear idea of the relief. South-west of Cape Van den Bosch (New Guinea) a narrow gully was found with a maximum depth of 2000 metres. No sill was found between the Kei and Aru troughs, but there is a continuous area with over 3000 m. between 4° 30′ and 6° 15′ S. The depth then diminishes regularly to the south-west and the Aru trough seems to be separated from that south of Timor by a rise with about 1600 m. In the channels connecting the Timor trough with the Banda Sea the greatest depths range between 800 and 1300 m. The ridge separating the Timor trough from the Indian Ocean showed 1940 m. at its lowest point (just south of Roti), falling regularly to 3300 m. in the trough itself. From a study of the distribution of temperature, salinity, and carbonic acid content it appears that oceanic water flows across the ridge into the trough, then taking on a movement of descent. The coldest water does not however penetrate far, but is mixed with the warmer and more saline water above, yet its influence on the temperature of the bottom water can be traced for a considerable distance. The channels leading north into the Savu Sea were examined with equal care and their greatest depths determined. Current measurements were also carried out in Savu Strait during two whole days.

The geologists took every opportunity of studying the structure of the region. South of Misol the existence of a great east-west anticline was established, consisting of a great thickness of Eocene and Cretaceous strata, with a narrow core of Jurassic exposed. Attention was paid to the problem of the narrow channels running through the Aru group, which have been the subject of various theories, none quite satisfactory. Dr. Kuenen regards them as a merely local phenomenon of the character of drowned river-courses. Their deepening outside the margin of the group is attributed to tidal currents. Work was also done at Wotap and

neighbouring coral reefs in the Tanimber group (that island itself proving to be composed almost entirely of sandstone), and a more lengthy stay was made on Timor for the collection of fossils, while samples of submarine deposits were taken by the special boring apparatus. Biological work was carried out wherever possible.

The investigations in the early part of 1930 were concerned with the waters between Celebes, Sumbawa, and Flores, but a summary of results here secured must be left for another occasion.

HURRICANES AND TROPICAL DEVELOPMENT

In *Economic Geography* for April 1930 Mr. Stephen S. Visher draws attention to the violence of rainfall and wind conditions, together with the high variability of the rainfall and its seasonal concentration, as factors to which due weight are not given among the recognized climatic factors hindering the development of the Tropics. The great destruction wrought by floods and tidal waves as well as the immense loss of life occasioned by hurricanes not only directly but also indirectly by famine and disease following in their wake, have, he points out, a pernicious influence on the outlook of tropical peoples, leading to indifference and lack of enterprise, so that every effort is called for on the part of modern governments in combatting the discouraging conditions which prevail in countries liable to destructive cyclones. In this connection one may instance the recent visitation in Santo Domingo which is typical of what occurs every year somewhere in the West Indian Islands during the hurricane season.

Mr. Visher quotes numerous statistics on the severity of weather brought by tropical cyclones. This may be judged from the fact that a rainfall exceeding 20 inches in twenty-four hours is by no means rare, and that there are instances on record of 80 to 90 inches falling at least locally in the three or four days sometimes required for the passage of one of these slow-moving revolving storms. It may be noted that it is just this slow rate of travel, rarely exceeding 10 miles an hour, that is the deadly feature of tropical cyclones, for it means that one place may be subject to hurricane winds of from 100 to 150 miles an hour with the accompanying deluge of rain for a couple of days or more. We may compare this with our own Atlantic winter storms which, travelling at from 30 to 50 miles an hour or more, have usually passed over within a few hours, even though they may sometimes follow one another in quick succession, and do not bring wind speeds over 100 miles an hour as a round figure.

NEW LIGHT ON TWO EARLY MAPS

Two separate notes, of interest for the history of cartography, appear in *Petermanns Mitteilungen*, Heft 5/6, 1930. The first, by Dr. R. Uhden, refers to the mediaeval map known by the name of Lambert of St. Omer, from its occurrence with the 'Liber Floridus' of that writer. It had previously been recognized (by Miller: 'Die ältesten Weltkarten,' Heft 3, 1895) as based on an earlier prototype, as it has little in common with the mediaeval wheel-maps. An inspection of the copy preserved at Wolfenbüttel convinced Dr. Uhden that it had no real connection with Lambert's work, and a closer scrutiny revealed a legend ascribing the authorship to Martianus Capella of Carthage, the sixth book of whose popular Encyclopaedia dealt with geography under the title 'Geometria,' and who held a proconsular post at Carthage in the fifth century. The correctness of the ascription is fully vouched for by the identity of various legends on the map (including that on the "Antichthones") with passages in the written work. The second note has to do with a hitherto unrecognized version of Georg Erlinger's woodcut map of Germany, brought out at Bamberg (where Erlinger was established as a printer

and woodcutter) in 1515. Its issue in that year is established by a printed leaflet lately found by Paul Diercke in the Wolfenbüttel copy of the Strasbourg Ptolemy of 1520. Issues of 1524 and 1530 were already known, and show that the map was a rough reproduction of Etzlaub's map of 1501. The text of the leaflet in question seems to indicate that the 1515 issue came still nearer that original. Herr Diercke thinks, in fact, that it may be identified with an unsigned and undated map preserved in the Liechtenstein collection at Vienna, which is virtually an exact copy of Etzlaub's map. He points out that the latter has a special interest as the first example of a woodcut printed in colours, and also (with its prototype of c. 1492) the first map to represent language-distribution. That it did so is proved by a leaflet printed to accompany the issue of 1492, and preserved in the MS. of Schedel's chronicle in the State library at Munich. This explains that the German-speaking area left white in the centre is surrounded by "seven kingdoms and languages, each of its own colour."

CORRESPONDENCE

THE TORRES—PRADO VOYAGE

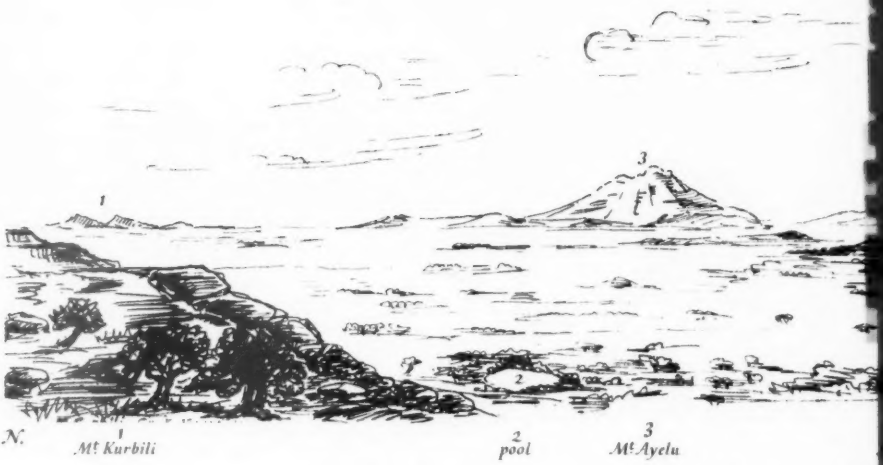
I have just seen a copy of your September issue. It is pleasant to see my name attached to a note on the Torres-Prado article; but in strict justice the discovery of the wrong eclipse-date is Captain Bayldon's rather than mine. If I had known names were to appear, I should have mentioned his. About the article itself I have two minor criticisms to make :

I should have thought the *Pera's* log a sufficiently "contemporary" witness. When a Dutchman in 1623, among several other references to the earlier voyage, writes : "We sailed past a large river which the men of the *Duyfken* went up with a boat in 1606," it seems hardly reasonable to suggest doubts of the earlier vessel's achievements.

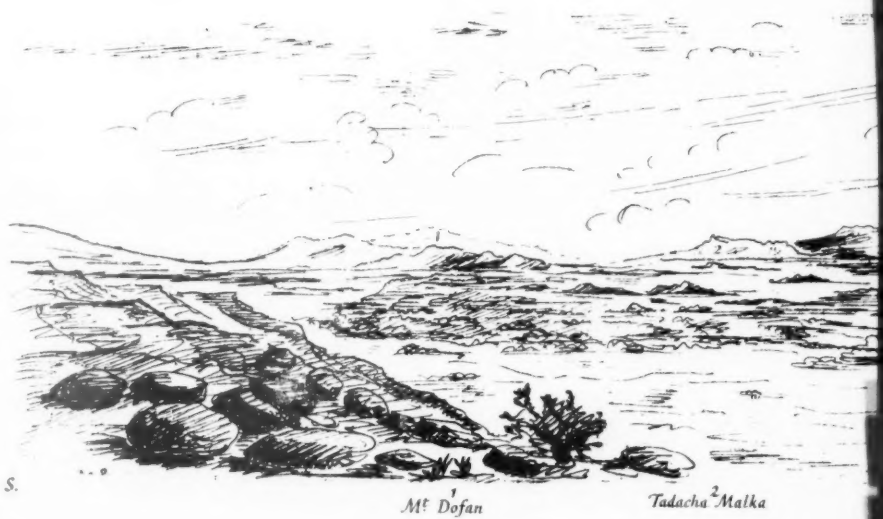
The article seems to me to miss one decisive proof that the voyagers did *not* go through Endeavour Strait. On p. 165 of the Prado narrative they reach a lofty cape which Stevens (correctly, I think) identifies with False Cape, and "It pleased God that at this cape we got away from the shoals."

It is inconceivable that a ship coming across open sea from the mouth of Endeavour Strait to False Cape could be said to get away from the shoals "at" False Cape. On the other hand a ship that had been coasting New Guinea westwards from long. 142° or thereabouts would be worried with shoals along a lee shore all the way to False Cape.

ARTHUR JOSE.

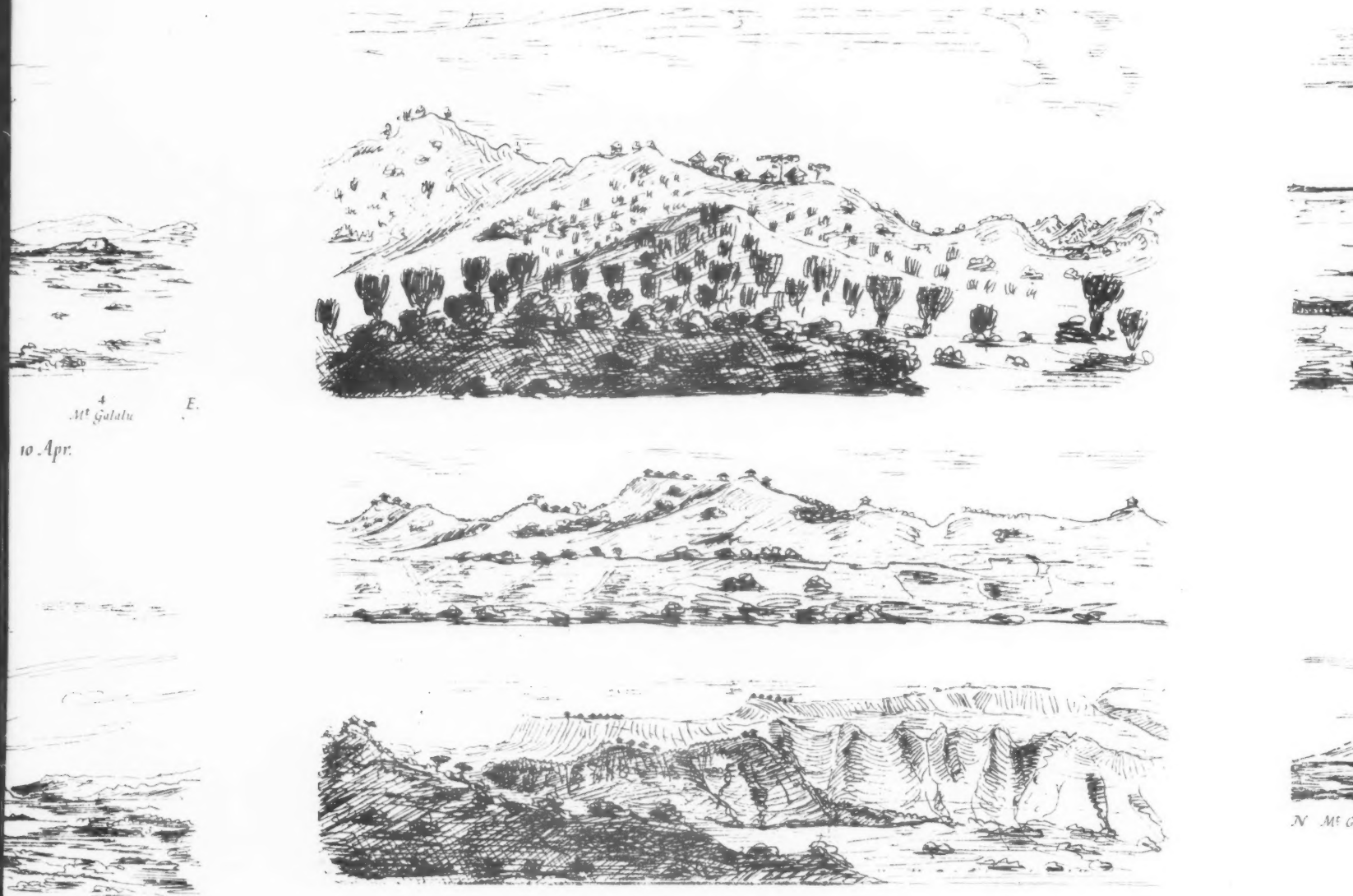


1. Mount Ayelu from camp near Dinikale Maru. 10 Apr

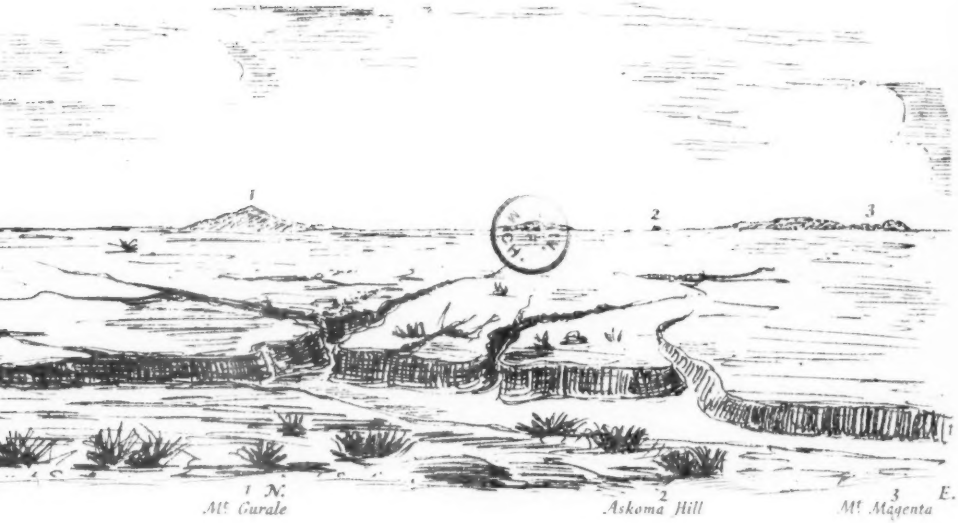


SKETCHES IN DANAKIL, 1928.

by L. M. Nesbitt.



3. Views north, east, and south from Erifible market near Mofa. 27 Apr.



5. *Desert erosion at Ladinigero. 2 May.*

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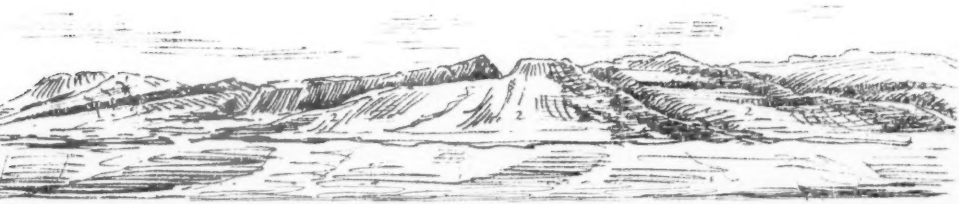
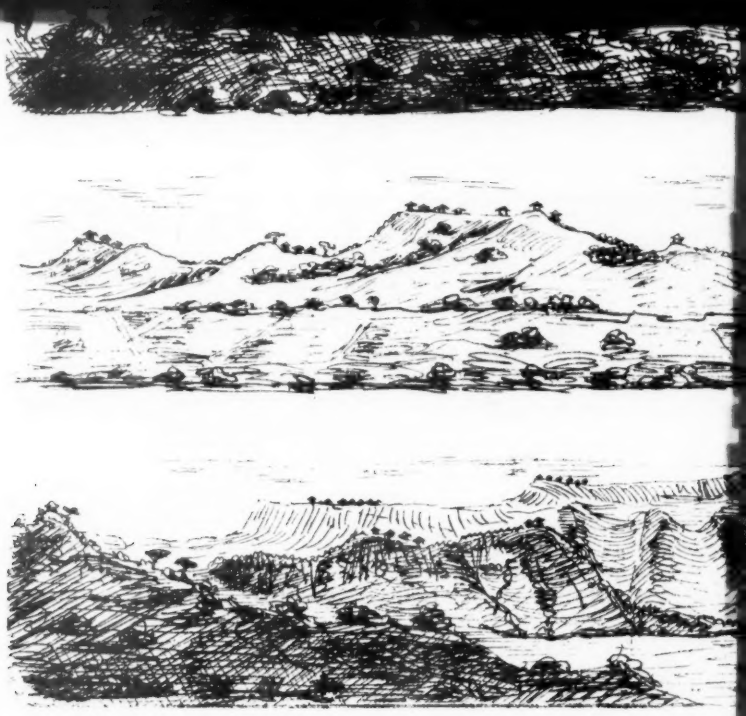


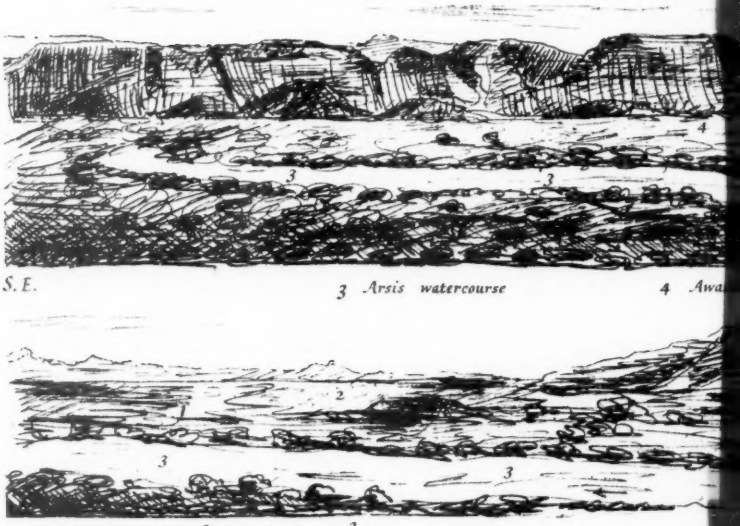
2 *Addaale Mountains*

1. Mount Ayelu from camp near Dinikale Maru. 10 Apr.

2. Panorama from plateau rim above Dinikale Maru. 10 Apr.



3. *Views north, east, and south from Erifible mark*



4. *Panorama south-east to south-west fro hill north of Arsis watercourse.*

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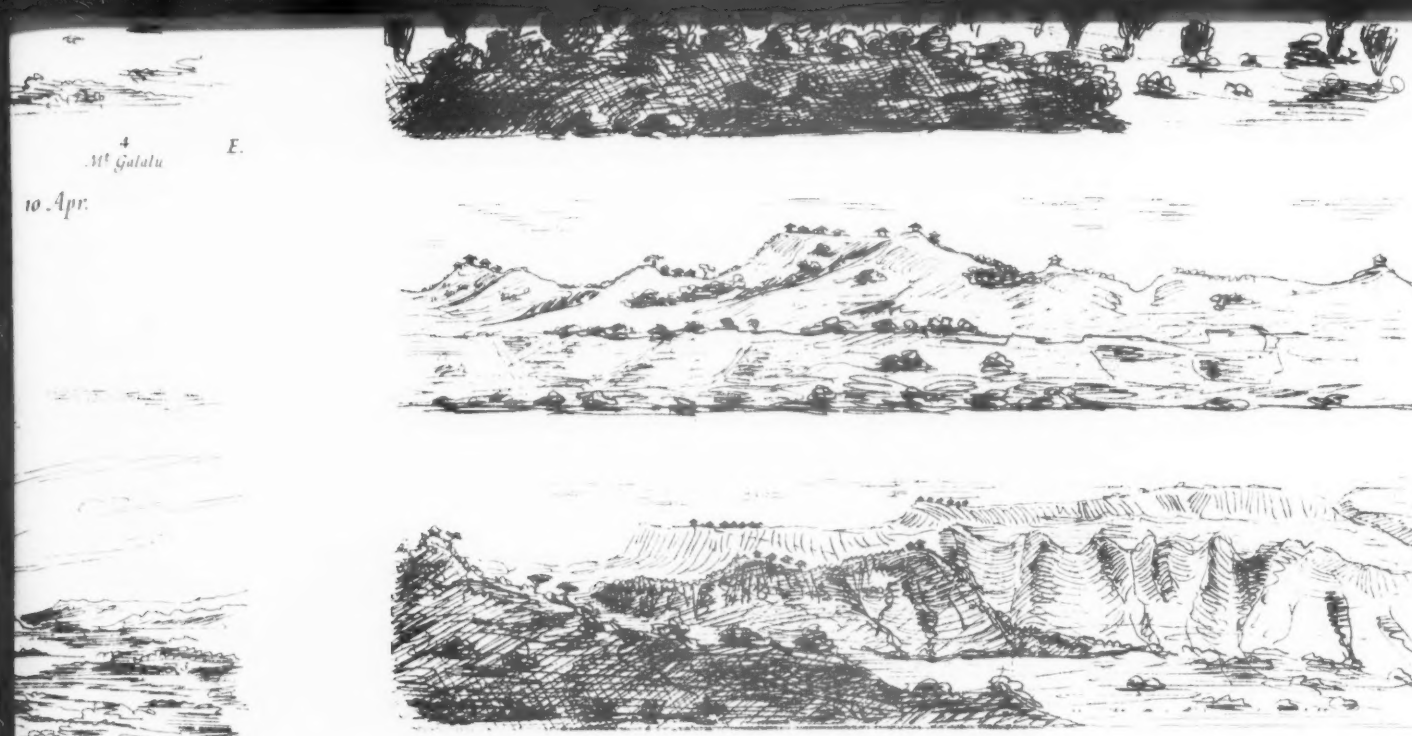
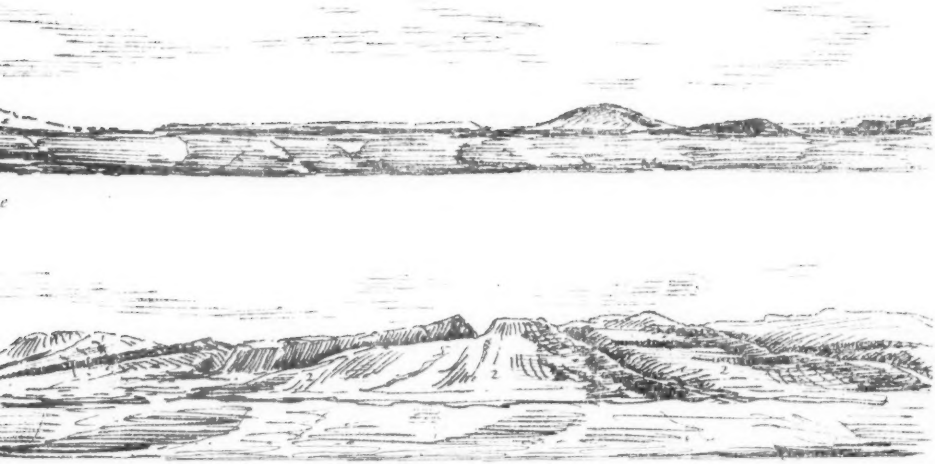


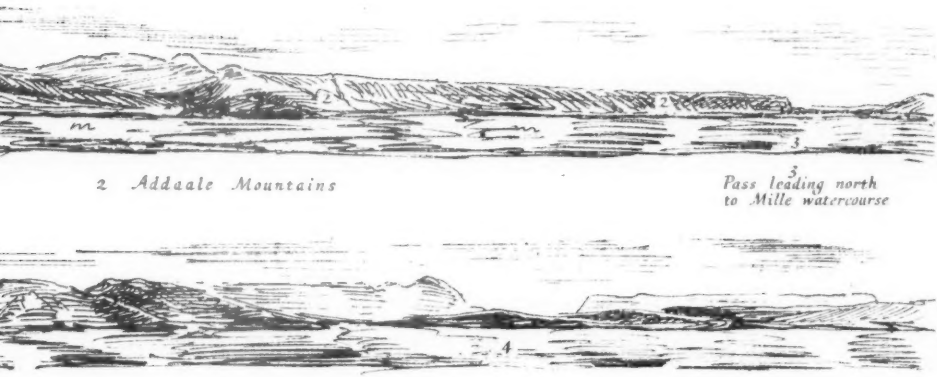
3. *Views north, east, and south from Erifible market near Mofa. 27 Apr.*

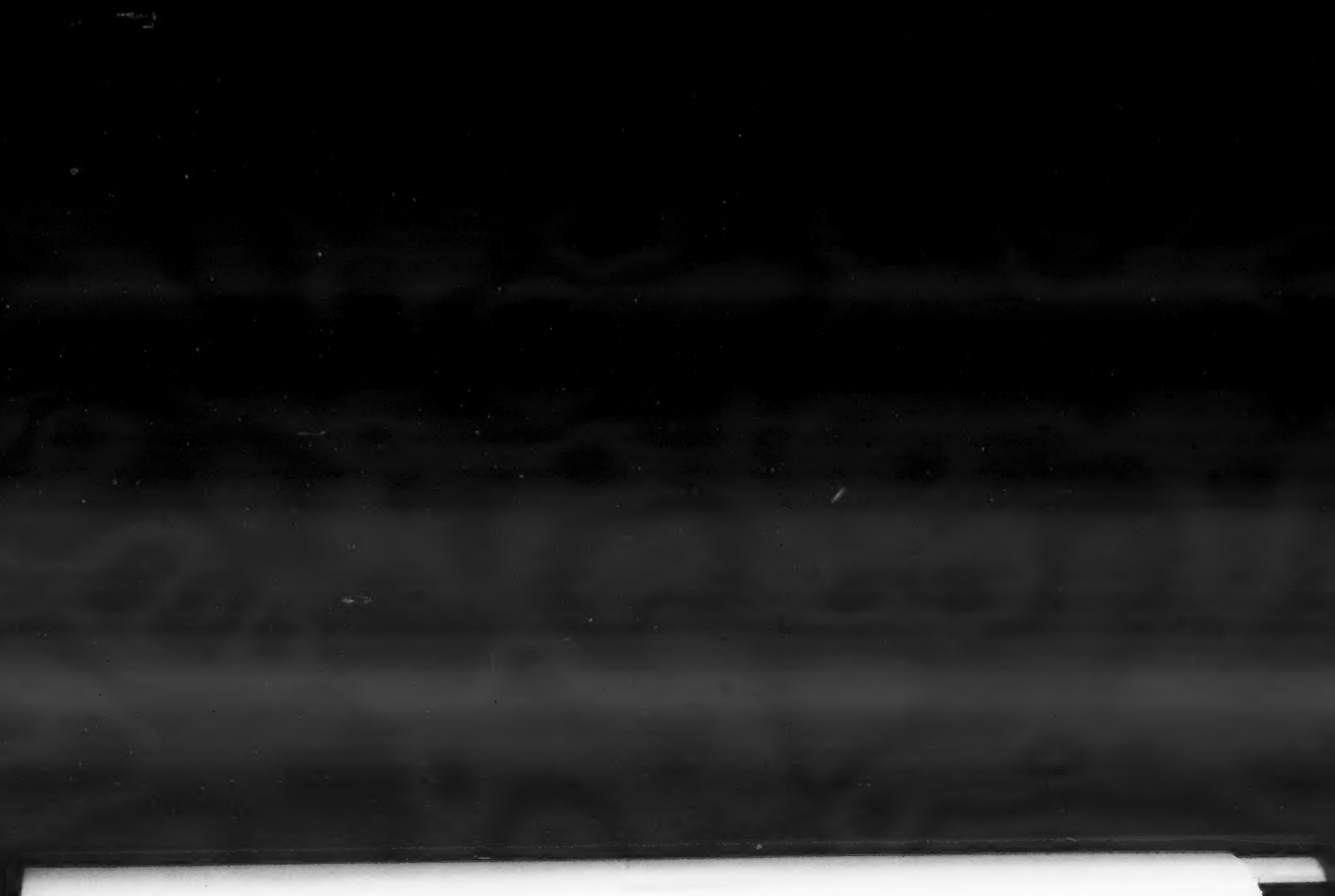
4. *Panorama south-east to south-west from basalt hill north of Arsis watercourse. 8 May.*

Published by the Royal Geographical Society

5. *Desert erosion at Ladinigero. 2 May.*





6. *Mt Gurale and the Addaale Mts from just north of Waranso watercourse. 6 May.*

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